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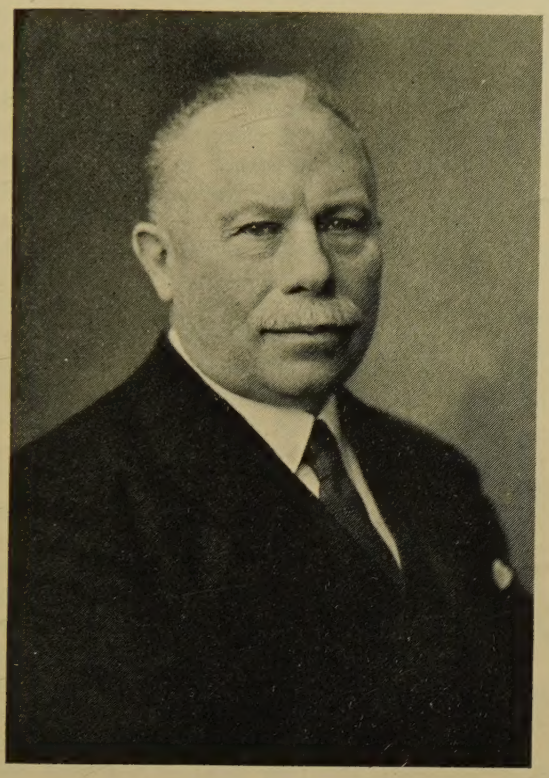


Martin Knudsen.

1871—1949.

IN the year 1899 a meeting in Stockholm led to the setting up of "The International Council for the Exploration of the Sea". Now, just 50 years later, Professor Martin Knudsen, the last of those who assisted at the Council's foundation, has passed away after having been active in the work of the Council for nearly the whole of that long span of years.

Martin Hans Christian Knudsen was born in Hasmark on the island of Funen on 15. February 1871, the son of a farmer. In 1890 he matriculated at the University of Copenhagen and took up the study of physics. His diligence

and outstanding talents brought him, even in his student days, various marks of recognition, including the University's gold medal. After he had passed his examinations in 1896 he became attached, as assistant, to the Polytechnic High School, and three years later to the University also, where he was lecturer from 1901—1912 and professor of physics from 1912 to 1941.

Martin Knudsen possessed a sound judgement and exceptional ability as an experimental physicist, and these qualities together with his creative imagination characterized his work both in pure physics and in oceanography. As a physicist he was particularly interested in the behaviour of gases at low pressure, and mainly during the years 1909—1917, he published a number of works in which he drew attention to several hitherto unnoticed consequences of the kinetic gas theory and verified these findings experimentally. He discovered, too, new characteristics of the gases and made important contributions to the understanding of the processes of evaporation and condensation.

Here, however, it is natural to concentrate especially on Martin Knudsen's contributions to oceanography. His interest in this branch of science was aroused when, as a physicist, he took part in the Danish "Ingolf" expedition to the waters around the Faroes, Iceland, and Greenland in the summers of 1895 and 1896. When one reads his report on the hydrographic investigations, published in 1899, one is impressed by the efficiency with which this young student, who had hitherto had no contact with oceanography, improved the technique of observation. This applies first and foremost to chlorine determination by Mohr's method, in which he introduced "Knudsen's pipette" for the quick and accurate measurement of a volume of sea water, and "standard water" for controlling the strength of the silver nitrate solution. He also improved the construction of the reversing thermometer, and designed and built a new apparatus for analysing the content of dissolved gases in sea water.

After Martin Knudsen's achievements on the "Ingolf" expedition, it was natural that the young scientist, then only 28 years old, should become one of Denmark's three delegates to the Stockholm conference in 1899. At this conference he put forward a suggestion for the setting up of "An International Institution for Procuring Standard Water", and descibed a practical method for obtaining a greater degree of accuracy in salinity determination. He became a member of a committee charged with the revision of the previously existing

hydrographic tables. The accomplishment of this work was entrusted to Martin Knudsen who directed it with great efficiency; he had the quality of being able to find the right assistants. Samples of sea water from different parts of the world were collected and the "constants" of the sea water were precisely determined, i.e., the relation between the amount of chlorine and the salinity, and between the amount of chlorine and the specific gravity at different temperatures. On the basis of these constants the well known "Hydrographical Tables" were drawn up. These tables made it possible to determine, by a simple procedure, the chlorine content, salinity, and specific gravity of a sample of sea water with great accuracy from a Mohr titration against "Standard Water". The book also contained tables for the calculation of salinity and specific gravity on the basis of hydrometric measurements. The whole of this extensive work was completed in 1901.

Martin Knudsen's contributions during these years, when the International Council for the Exploration of the Sea was in embryo, can hardly be overestimated. To him belongs most of the credit for the introduction, immediately after the setting up of the Council in 1902, of a method for salinity determination on an experimental basis, which was so well worked out that over a period of nearly half a century it has not been necessary to make any change. As a result, the thousands of salinity determinations which, in the course of time, have been published by the Council and others are directly comparable, regardless of the time and place at which they were carried out. One can only regret that he did not succeed in winning general agreement on his proposal to employ the halogen content as an expression for the content of dissolved salts in sea water instead of the "salinity". Both from a practical and a theoretical point of view this practice would have been preferable, as pointed out in his report on the hydrographical investigations of the "Ingolf" expedition.

The production of "Standard Water", after the establishment of the Council, was transferred to the Central Laboratory in Oslo. In 1908 it was entrusted to Martin Knudsen, and from that time he remained in charge of the production right up to his death. When the supply of the original "Primary Standard Water", to which the chlorine content of ordinary "Standard Water" is referred, was almost used up in the 'thirties, he undertook, together with J. P. Jacobsen, the production of a new supply of "Primary Standard Water". In connexion with this an alteration in the definition of Cl $^{0}/_{00}$ was made,

by which it was brought into relationship with pure atomic silver. This meant that chlorine determinations would always be directly comparable with older determinations regardless of changes in the agreed values of the atomic weights of the elements. At the same time the silver provided a standard which was more suitable for keeping over a long period of time than sea water.

From the very start of the Council Martin Knudsen took an active part in its work and attended all the meetings from 1902 to 1947, as a delegate and for the last 14 years as a vice-president. He edited the "Bulletin Hydrographique" from 1902 to 1948 and was chairman of the hydrographic committee for 22 years from its foundation in its present form in 1925.

To Danish investigations of the sea Martin Knudsen also made an important contribution as a member of the Commission for the Study of the Sea and leader of the Commission's Hydrographical Laboratory from 1902 to 1948. His papers on hydrography number about 40 and can be divided into two groups, those on method and those on special hydrographic researches. In the first group especially there are works which will keep his name alive for many years. Among these may also be numbered the apparatus he constructed, especially the different types of water bottles which have been widely used.

Martin Knudsen's contribution to oceanography cannot, however, be measured by his publications alone. His sound judgement and his powers of negotiation coupled with great professional insight procured for him an influence which he used to the lasting benefit of oceanography in many different spheres. It was, amongst other things, due in a great measure to him that Charlottenlund Slot was placed at the disposal of the Danish institutions for the Study of the Sea and of the Central Bureau of the Council, just as the establishment of Denmark's Aquarium and Denmark's Fishery College was very largely the result of his initiative and endeavour. During the last war he rendered a service of vital importance to the Council when by application to the Danish Government he succeeded in getting sufficient financial assistance to enable the Council's staff and capital to be maintained intact throughout the war, so that everything stood ready for work to be taken up again immediately the war ended.

He also took part in the work of the "Association d'Océanographie Physique" and was president of this organization from 1930 to 1936.

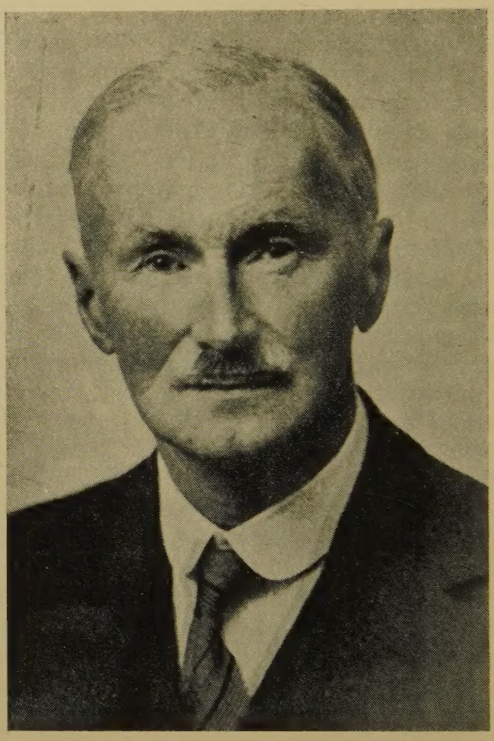
As already mentioned, oceanography was only one side of

Martin Knudsen's activities. Along with his teaching and research work at the University of Copenhagen he found time to compile several text books on physics, and in addition, he placed his unusual powers as organizer and administrator at the disposal of so many different interests that it would take too long even to name them here. He gave much of his time to "Det Kongelige Danske Videnskabernes Selskab" ("The Royal Danish Academy of Science and Letters"), of which he became a member in 1909 and of which he was secretary from 1917 to 1945. He was *Rector magnificus* of the University of Copenhagen from 1927 to 1928.

Martin Knudsen was a man who got through more work than most people, and few sought his help and advice in vain. He was fortunate in having the satisfaction of seeing his work widely appreciated, both in his own country and abroad. Among the scientific distinctions which he received mention may be made of an honorary doctor's degree at Lund University, and the "H. C. Ørsted Medal" and the "Agassiz Medal". Besides these he was a member of several Danish and foreign scientific societies. His own country bestowed upon him the cross of Commander (first class) of the Order of Dannebrog.

Martin Knudsen's matter-of-fact, unassuming, and friendly nature made it easy to collaborate with him and won him a large circle of friends, both at home and among the many foreign scientists he came in contact with. It is sad to think that the last of the great pioneers within the Council has now passed away. May their names always be remembered with respect and veneration.

Helge Thomsen.



George Philip Farran.

1876—1949.

GEORGE PHILIP FARRAN, who died at his home, Knocklyon, Templeogue, Co. Dublin, on 5. January 1949, at the age of 72, was the elder son of the late Edmond Chomley Farran and his wife, Anne Hume (née Ryan). He was born at Templeogue on 21. November 1876 and was educated at the Reverend Benson's school at Rathmines, Dublin. He entered Trinity College, Dublin, in 1895. Although originally intended for the law — Farran actually entered the Law School at Trinity College, Dublin — after a distinguished academic career he graduated in Natural Science obtaining the

Gold Medal in that subject for his year. In 1898 he joined the small group of scientists collected by the late Ernest W. L. Holt to work on fishery and marine biological problems at the marine laboratory at Ballynakill, Co. Galway. After the foundation of the Department of Agriculture and Technical Instruction in 1900 Farran joined its staff as a naturalist and he remained with the Department until his retirement in 1946. In 1938 he was appointed Chief Inspector of Fisheries in succession to his life-long colleague, the late Charles Green.

Farran's early papers ranged over a wide field of marine zoology but later he devoted himself almost entirely to the study of planktonic organisms, particularly copepods, and of the herring shoals around the Irish coasts. Before the first World War most of his papers were published in the *Scientific Investigations* of the Fisheries Branch of the Department of Agriculture and Technical Instruction, but later he contributed to other journals including those of the Royal Irish Academy, the Zoological Society, London, the Linnean Society, and the International Council for the Exploration of the Sea, the *Annals and Magazine of Natural History*, the *Irish Naturalists' Journal*, and many others.

The high regard which other scientists had for his work on plankton brought him material from all over the world. He worked up the copepod material from the Great Barrier Reef and a number of other expeditions.

Towards the end of his official career administrative duties prevented him from doing as much scientific work as he would have liked. On his retirement he continued to work on planktonic organisms and at the time of his death he was engaged on investigating material from some very deep hauls made off the south-west coast of Ireland. He told the writer towards the end of 1948 that some interesting species were present in this material. In the summers of 1947 and 1948 he was engaged for a time experimenting with the breeding of oysters in tanks at Cromane, Co. Kerry, in the south-west of Ireland.

From 1920 until his retirement in 1946 Farran attended most of the meetings of the International Council for the Exploration of the Sea, at first as an expert, for three years as a guest, and later as a delegate, and he never missed an opportunity of stressing the necessity for international co-operation in fisheries research in Europe.

He was elected a member of the Royal Irish Academy in 1912 and served for many years on its Fauna and Flora Committee. In 1948 Farran was elected an honorary member of

the Challenger Society in recognition of his work in marine biology. Whilst lesser men were obtaining doctor's degrees of various universities, F a r r a n to the end was content with his B. A., although with his publications he could have had his doctor's degree "for the asking", but ask he would not.

F a r r a n' s interests outside his professional work were very wide. Although most of his work was connected with the sea he was a fine all-round naturalist. He could be seen quite frequently in the Dublin libraries searching for historical material relating to the parish in which he and his family had resided for many years. The garden at his home, a fine old Georgian house outside Dublin, received much of his attention. Although he took little active part in the organization of the societies, he was a member of many of the more important cultural bodies in Dublin. His paper "Irish Names of Fishes" published in the *Irish Naturalists' Journal* in 1945/46 was an amazing piece of work which could only have been done by a painstaking individual like F a r r a n. Although not a Gaelic scholar F a r r a n' s phonetic sense enabled him to record the Gaelic names of many rare fishes. His researches took a period of twenty-five years to complete. Information from fishermen, teachers, and others who had worth-while contributions to make to this study was eagerly sought. One of my most vivid memories of F a r r a n was a discussion he had with a fishwife at Galway in the west of Ireland as to what was a "fishoge". This species had eluded F a r r a n for years and after half an hour's discussion still eluded him, but notwithstanding this he collected a considerable amount of extra data for his records.

In 1920 F a r r a n married Georgina Margaret C r a i g by whom he had a son and a daughter. In 1941 almost on his 65th birthday whilst engaged on duties in connexion with a volunteer emergency police force F a r r a n was unfortunate enough to break his leg and for some months was in hospital. He made, however, a good recovery and was able to resume his official duties after several months. Just before the end of the second World War his son was posted missing on a flight with the Royal Air Force and although he survived as a wounded prisoner, the period of anxiety affected even F a r r a n' s calm disposition. It was obvious to those who knew him well that the death in 1945 of his wife, to whom he was devoted, was a considerable shock but F a r r a n found relief in his work.

Retiring in disposition, F a r r a n seldom took part in a discussion unless he had some definite contribution to make. To his junior colleagues he was always helpful; he spent much time

searching for material for people outside the Department and helping them in every possible way with their scientific work. A conscientious worker himself, Farran expected others to give of their best and if they did not he had little use for them. Farran treated everyone with the utmost courtesy and respect and not the least his subordinate officers. As Farran's colleague for over ten years I have always appreciated his kindly disposition, and help and assistance freely given on every occasion.

He was the last of the team of workers including Kemp, Tattersall, and Green, assembled by Holt in the closing months of the last century, who did so much for Irish marine biology and fisheries. In their bereavement our deepest sympathy goes out to his son, his daughter, and his only surviving sister.

Arthur E. J. Went.

François Liebert.

1882—1948.

IN the autumn of the year 1908 a cheerful youth entered the service of the Dutch State Institute for the Exploration of the Sea (as it was then called) at den Helder. Coming fresh from the Technical High School of Delft, he took up his tasks enthusiastically. Not only hydrography, but also bacteriology, and the many problems connected with the preservation of fish and shellfish, were the objects of his industry and interest, and in the forty years of his life in this rather remote corner of our country he devoted himself wholly to his work. He was at first an assistant to Dr. H. C. Redeke, and in 1919 became

Director of a separate Institute of Chemical, Microbiological, and Hydrographical Fishery Research at the same place.

He produced more than 25 papers, mostly short, in this extended field of investigations. It was particularly questions which affected fishermen and fish merchants to which his practical and technical mind felt attracted and which he solved successfully. Amongst other things may be mentioned his researches on the preservation of herrings and shrimps, on current measurements, on the metabolism of nitrogenous compounds and the action of bacteria on them, on oysters "turning green", on fish mortality in inland waters, on enzymes and salted herrings, etc. In addition, he published from time to time practical hints on microscopical photography and devised several ingenious physical instruments. Most of his papers appeared in Dutch in divers periodicals.

The older members of our Council will remember his buoyant personality, for he attended general meetings in 1909, 1921, 1929 (in London), 1935, and 1937. He was also present at the meeting of plaice experts in March 1925 in Amsterdam, and that in October 1932, when, again convened by the Council, experts on international standardization of bacteriological control of oysters were assembled at Middelburg.

Though his rather delicate health caused him sometimes severe trouble he retained throughout a characteristic, boyish jocosity and a lively sense of humour, which even an occasional spell of physical depression could not wholly suppress. His frankness and open-mindedness, his modesty and his ever-ready hospitality won him many friends, and meeting him was always refreshing. His criticisms were always mild.

The years of the late war were trying for him. Soon after Holland's capitulation he was forced to evacuate his home, with nearly all the inhabitants of his town, and could only continue his work by travelling daily to and fro from a place about 40 Km. distant, till he was obliged by the Germans to abandon his task altogether. After the deliverance he resumed work, but he could not quite recover and was never the same again. His rather sudden death on 29. January 1948 is sincerely to be deplored.

He left a wife and two sons.

J. J. Tesch.

Some Notes on the Determination of the Chlorinity of Sea Water by Comparison with the International Standard.

By

J. King,

Government Laboratory, London.

THE technique of O x n e r (1920) for the M o h r titration method for the determination of the chlorinity of sea water has been widely used in connexion with oceanography since 1920 and is still generally accepted. G i r a l (1926) queried the use of glass containers for the storage of standard samples of sea water, maintaining that the chlorine content is altered by the attack due to the sea water on the constituents of the glass. The silicate ion was also assumed to pass into solution resulting in an additional ion precipitable by the silver nitrate solution in the course of titration. G i r a l remarked on the visible attack on the glass in spite of the quality now used and cast doubts on the constancy of the ratio between the salts in sea waters in different localities.

The attack on glass brought about by long contact with saline solutions appears to be a well-known phenomenon. The British Pharmacopoeia 1948, pp. 282—283, calls attention to the separation of small particles when saline solutions prepared for injections are stored in ampoules, thus rendering them unusable. Some standards of P. 9 sealed at Copenhagen in 1920 which have been in our possession since that date and stored in the dark at laboratory temperatures have developed this condition to such a degree (Fig. 1) that investigation appeared to be desirable. Particles taken from one of these samples proved to be composed entirely of glass and the X-ray diffraction pattern exhibited a typical crystal structure similar to, but not identical with, nontronite, a hydrated silicate of iron. The crystals (Fig. 2) were in the form of extremely thin plates which gave interference colours in daylight when dry. An examination of the liquid contents showed that the silica

content was 20 mg. per litre as SiO_2, compared with 2·5 mg. per litre in samples of P. 16 (1943), 4·4 mg. per litre in P. 15 (1937), and 0·02—7 mg. in fresh sea waters. There was little change in pH, however, that of samples of P. 9 ranging from 7·66 to 7·85 compared with 7·44 for P. 16. In view of these results and bearing in mind G i r a l' s criticisms it was a matter of interest to determine the chlorinities of P. 9 (1920) and P. 16 (1943) with as high a precision as possible.

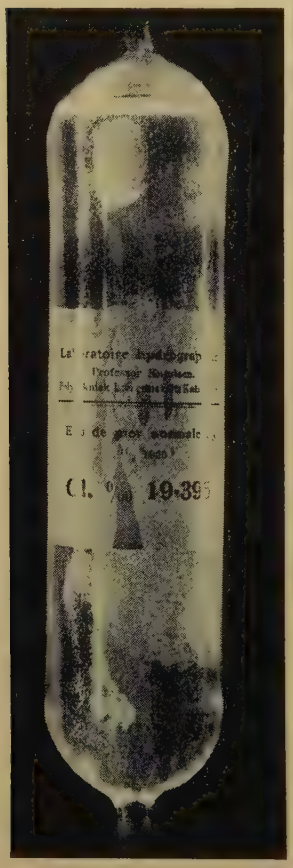


Figure 1.

Figure 2.

Three samples of P. 9, all of which exhibited pronounced attack on the glass of the container, were examined in July 1948 by the Oxner technique using P. 16 as the standard, and all were found to have a chlorinity of 19·40 ‰ compared with 19·395 ‰ when issued from Copenhagen in 1920. A sample of P. 15 (1937) kept under laboratory conditions until August 1948 was free from visible attack on the glass, and the chlorinity was then 19·39 ‰ compared with 19·393 ‰ when issued, the pH being 7·68 (all pH determinations were carried out at 20°C. using a glass electrode, and a calomel cell as reference). So far as

the Mohr titration of sea water is concerned, silicates are without any effect, as the solubility of silver silicate has been found to be greater than that of silver chromate, the colour of which appears before any of the silicate is precipitated. These findings do not support Giral's contentions, but it appeared desirable to investigate the precision of the Oxner technique and the continuity of the standard sea waters as closely as possible.

Numerous criticisms of the accuracy of Oxner's method of carrying out the Mohr titration have been made by Giral (*loc. cit.*) and others, and Anderson (1948) has proposed a conductimetric method, duplicates of which are claimed to have five times the precision of the Oxner technique. Deacon (1933) has confirmed the accuracy of P. 13 by comparison with pure NaCl, but more recently Jacobsen and Knudsen (1937) have proposed as the reference standard a prototype sample of pure silver. Hönigschmid has determined that the amount of this silver — prepared in connexion with his well-known investigations on atomic weights — required to precipitate the total halogens in 1 Kg. of the Urnormal 1937 is 58·99428 g. This figure henceforth forms the basis for the standardization of all sea waters, Hönigschmid having deposited 100 g. of this silver with the International Commission. U. 1937 was related directly to the standards formerly issued by direct titration, the chlorinity of these being taken as the issued figures. A slight increase in the chlorinity of standard VIa stored in glass ampoules of a type used in the collection of samples for gas analysis has been reported, Cons. Perm. Internat. (1909), but the composition of this glass was probably different from that used in making the containers for the "P" series of standards. We have not been able to detect by the technique described later any significant change in chlorinity on the storage of P. 9 for 28 years. This seems to confirm Knudsen's contention that the solution of glass in the sea water makes no measurable difference to the volume, Cons. Perm. Internat. (1903). A nephelometric determination on a weight basis would be expected to show a difference, partly on account of the silicate ions present, and partly because the percentage by weight of halides present would be less in sea water which had dissolved significant amounts of silicates on storage, on account of the increase in total weight due to solution of the glass, but it may be that these two errors which act in opposite directions balance each other. According to Aston (1941), the figure of 107·880 for the atomic weight for Hönigschmid's silver is of exceptional trustworthiness, and it is most unlikely that subsequent preparations of silver will contain relative abundances of the two isotopes of 107 and 109 mass numbers differing from that of this sample. The adoption of Hönigschmid's figure of 58·99428 g. as the standard appears desirable therefore from all points of view.

Since silver is now adopted as the reference in preparing sea water standards, it is of interest to quote here the work of Dr. A. G. Francis, Deputy Government Chemist, 1937—1946, carried out in the

Government Laboratory in 1923, hitherto unpublished but now quoted with his permission. Three sea waters from widely separated localities were collected in the following areas and forwarded to the laboratory in Winchester quarts:—

(a) The Great Belt by Dr. A. C. Johansen
(b) The Atlantic by Mr. G. P. Farran
(c) The Eastern Mediterranean by Mr. E. R. Saiver

The total halides as chlorine were estimated in these three samples observing the meticulous precautions described in the determination of the atomic weight of strontium by Thorpe and Francis (1910). The end point in the titration was obtained by the nephelometric method of Richards and Wells (1905). The silver used as a standard was part of that prepared for the strontium investigation and assayed by the Chief Assayer of the Royal Mint to contain 99·994 % of silver. It is not possible to state how this silver compared with that of Hönigschmid, but is is unlikely that the difference is significant, and would certainly be less than could be detectable by the Oxner technique of carrying out the Mohr titration. The following results were obtained on the sea waters quoted above, and for a sample of standard sea water P. 10, calculations being based on atomic weights of 35·460 for chlorine and 107·880 for silver, all weights being computed to vacuum throughout.

Source of sea water	‰ Cl by nephelometric method	‰ Cl by Mohr titration
Great Belt	5·6616	5·65
Atlantic	19·6698	19·64
E. Mediterranean	21·4090	21·365
Standard P. 10	19·3990	19·383

Copenhagen figure.

In each case the results quoted are the mean of three determinations. The figures would probably have been still more closely in agreement if the precautions in carrying out the Mohr titrations now found necessary and enumerated below had been observed, and if the method of collecting and transmitting the samples had been similar to that adopted for the U. 1937 standard.

The determination of the chlorinity of sea water by the Mohr titration using the international standards supplied from the Copenhagen laboratory is an empirical method of comparison. Experience has shown that meticulous attention to detail is essential, as unlike an absolute method, results obtained by it cannot be checked rigorously by an alternative method as a matter of routine. Any modification of the Oxner and Knudsen technique can only be allowed if it reduces the standard deviation in the results computed statistically. Any movement from the mean would bring about a deviation from the result which is obtained by an internationally accepted method. The excellent directions given by Oxner (1920) must be followed rigorously. It may be helpful, however, to

place on record here the accumulated knowledge gained in carrying out over 132,000 determinations during the last 34 years in the Government Laboratory.

Inaccuracies in precision volumetric estimations such as chlorinity determinations arise from a number of causes, including slight faults in apparatus, differences in manipulation, changing temperatures, and impurities in reagents. The Knudsen pattern burettes of German manufacture which were issued from Copenhagen for many years, though of excellent workmanship and made from carefully selected glass tubing, were not of the true bore of the modern precision tubing. On recalibration, errors of a least 0·02 ml. were frequent, but these are not of great importance provided changes in the bore are not sudden, and that these rapid changes do not occur at points on the burette where readings are taken. Furthermore it frequently happens that the standard and sample are read at nearly the same point on the burette. These burettes were originally calibrated at 17·5°C., an appreciably lower temperature than the modern figure of 20°C. now used for all volumetric glassware in this country. This is not important provided that the sea water and the silver nitrate solution are at the same temperature, although there may be slight differences in the coefficient of expansion of the two liquids and between the glass of which the burette and pipette are made. Much more serious is the difficulty in delivering precisely the same volume of the silver nitrate solution as indicated by a given burette reading on all occasions. The filling of the burette for its calibration and for working purposes must be carried out in precisely the same way. Some of the burettes issued from Copenhagen were constructed so that the upper jet was bent at an angle, and ground so that drops of silver nitrate solution could not form. Another pattern had the jet pointing upwards, which enabled drops of unequal size to be retained on the orifice after filling unless precautions were taken to remove them. It is essential to have the exterior of this jet thoroughly clean and wetted with silver nitrate solution. The drop which forms on filling is then gently removed by touching the side of the jet with a glass rod in the same way as that used in detaching the drop from the bottom jet immediately before carrying out a titration. The error given by neglecting this precaution may amount to 0·02 ‰ Cl. The time taken for each titration must be uniform, and in calibrating the burette the liquid should be delivered for weighing exactly as though a titration was in progress (Schloesser 1907). It is preferable to use the silver nitrate solution for this calibration, although we have found little difference between the results obtained from the use of this and distilled water (Schloesser 1906). The use of a black paper band sharpens the meniscus reading appreciably (Stott 1928) and the use of a parallax-avoiding lens or binoculars is of assistance. We prefer to clean the burette and pipette when necessary by filling with a solution of NaOH — 8 % in industrial methylated spirit — allowing to stand a few minutes, draining, and then drawing in a few ml. of concentrated HNO_3. This is quicker and more effective

than the usual chromic acid mixture. As lubricant for the taps a stiff type of petrolatum appears to be as good as any of the special compound tap greases, but constant check on tap leakage is necessary. The burette when not in use is kept filled with the silver nitrate solution and covered to keep out light. The dark deposit which forms in time is not troublesome and may be rapidly removed by the method of cleaning advocated. The top of the burette is covered by an inverted wide specimen tube to prevent access of dust. In carrying out the titration we find it difficult to break up the precipitate of silver chloride in the beaker described by Oxner, and prefer to use a 7-inch white porcelain round-bottomed dish of almost truly hemispherical shape. It is easy to disperse the precipitate with a rubber-tipped glass rod in such a dish, and observation of the colour and its comparison with a preceding titration can be accurately carried out. As Prof. Knudsen pointed out to us when on a visit some years ago there is some risk of splashing from the flow of silver nitrate solution, but long experience has shown that the careful operator can avoid this and there is a gain in accuracy by its use. The amount of chlorine ions adsorbed in the first stages of the titration by the AgCl depends on its surface area. Reduction to the finest possible state of division must therefore be uniform in order to bring about the sudden change in ionic adsorption when the silver nitrate is in slight excess, so that the adsorbed chlorine ions pass back rapidly into solution and do not remain adsorbed by unbroken aggregates of AgCl (Kolthoff and Stenger 1942). Thorough grinding of the precipitate is therefore essential, and the mechanical difficulties are best overcome by using a thick glass rod the end of which is inserted into a hemispherical rubber tip made from a rubber bung. This grinding necessitates vigorous application, and avoidance of splashing is only attained by experience in using the basin and stirring rod advocated. In order to prevent the stratification of the silver nitrate solution, air at approximately the same relative humidity and free from dust should be rapidly blown through the reservoir at intervals. This can be done by passing the air by suction with an ordinary laboratory water-pump through two wash-bottles of water prior to its passage through the silver nitrate solution. Titrations should be carried out in a temperature-controlled room. This need not be of elaborate construction, and differences from summer to winter, but not during the day, are allowable. In order that the concentration of the silver nitrate solution may be checked at intervals during the day's working, we have made it a practice for some years to retain all samples of sea water sent in for examination which closely approach in salinity the latest issued standard from Copenhagen. These are blended until they are of precisely the same chlorinity as the standard and the mixture is then stored in small sealed bottles. Although this requires considerable skill and industry, we have found that the ready availability of a sub-standard for constant checks on the silver nitrate solution is well worth while. Frequent checks with a standard issued from Copenhagen are also carried out, but since these are hardly for continuous use,

the sub-standard enables checks throughout the day to be made a matter of routine. We find it advantageous to use a daylight lamp in a partially darkened room, giving approximately the same spectrum distribution as a north daylight — illuminant SB of the 1931 Commission Internationale de l'Eclairage. We test the colour vision of all our operators using charts such as the Ishihara series. Oxner's directions regarding the amount of K_2CrO_4 to be added as indicator, viz., 6 drops of 8 % solution are not precise. We find that drops delivered from an ordinary 1 ml. straight sided pipette average 0·05 ml., but may vary considerably depending on the type of orifice. The theoretical aspects of the use of K_2CrO_4 as indicator in the Mohr titration have been discussed by Kolthoff and Stenger (1942). From their practical observations (Kolthoff and Stenger 1947) they recommend the presence of 1—2 ml. of a 5 % solution per 100 ml. of liquid. We have found that the experienced operator is best able to judge the end point when 0·05 g. is present in the final volume of fluid which is normally 50—55 ml., thus agreeing with the maximum indicated by Kolthoff and Stenger, but considerably more than that advocated by Oxner. Dupré (1880), has advocated the use of a glass cell containing a solution of K_2CrO_4 as a light filter in carrying out the Mohr titration, and Hickman and Linstead (1922) have tried the effect of dyed gelatine filters for other titrations. Our experience with filtered orange or yellow light confirms Dupré's observation that a sharper end point is obtained, but continuous working in such a light is greatly disliked by the operators. The difference in the amount of K_2CrO_4 advocated by different workers appears to be a light filter phenomenon, the operator unconsciously using the supernatant K_2CrO_4 solution as a filter for sharpening the end point. Since Oxner's technique uses a straight sided beaker, his depth of solution through which the orange coloured Ag_2CrO_4 is observed is greater than that due to the use of a porcelain dish. The concentration of K_2CrO_4 required by Oxner is therefore less than by Kolthoff and Stenger or by ourselves.

Finally, we have concluded that the average routine worker can obtain with certainty successive results within 0·02 ‰ Cl. The experienced operator can attain results reliable to 0·01 ‰ Cl., but only after considerable practice and observing all the known precautions. Greater accuracy than this is not attainable by the Mohr titration and needs the nephelometric technique of Richards and Wells (*loc. cit.*).

The author desires to express his thanks for the help of his colleagues who have collaborated in this study, to Dr. A. G. Francis for access to his original work, and to the Government Chemist for permission to publish this record.

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Ammonia Determination in Sea Water.

By

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SMALL quantities of ammonia in water are generally determined colorimetrically with Nessler's reagent and estimation of the intensity of the yellow colour by means of a photometer or a colorimeter.

The water sample should be clear and without colouring. The method is satisfactory in most freshwater investigations. When analysing sea water the difficulty arises that the Nessler reaction, which has to take place in alkaline solution, produces a precipitate of magnesium and calcium compounds with the result that the liquid turns turbid and colorimetry is made impossible. In order to avoid this difficulty the sodium hydroxide is added to the sea water and ammonia is distilled into a receiver, where it is determined colorimetrically or titrimetrically.

This method is rather awkward and various sources of error enter in it. Witting and Buch (1), therefore, worked out a new method, the sulphate, magnesium, and calcium ions of the sea water being precipitated by the addition of barium chloride, sodium carbonate and sodium hydroxide. The precipitate settles fairly quickly and it is possible to determine ammonia through direct Nesslerization of the decanted fluid. For analyses of sea water on board, this method is also too complicated.

Wattenberg (2) showed that it is possible to determine ammonia in sea water directly, if tartaric acid is first added to the sea-water sample and this mixture is then added to a strong sodium hydroxide solution and then Nessler's reagent added. The sample remained clear for hours or even for days.

Wattenberg's method does not seem to succeed in all cases. Thus, Braarud and Klem (3), using the method during a survey in Norwegian coastal waters off Möre, found that too many samples turned turbid and consequently could not be analysed by means of the colorimeter.

The method has, however, several advantages when compared with other methods. When ammonia analyses were included in the chemical programme of the Oslofjord survey, we found it, therefore, worth while

to try to work out a modification of Wattenberg's recipe, whereby his method might be used in our investigations.

Two lines might be followed. The first, to study the effect of the reagents upon the development of the colour, and the possibility of reducing the time which must elapse between the addition of the reagents and the colorimetry; the second, to study the connexion between the reagents and the process resulting in turbidity in order to find means of retarding it.

For these experiments, reagents according to Wattenberg's recipe were used:—

a) Salt seignette[1]) 30 % solution in water

b) Solution of sodium hydroxide 20 % in water

c) As Nessler's reagent a 5·5 % KI solution was used, in which had been dissolved as much HgI_2 as possible.

The colorimeter had cuvettes 30 cm. long. One of the cuvettes had a tube at the base and was connected with a niveau bulb by means of rubber tubing in such a manner that the column of fluid could be varied and its height read from a scale.

To study the relation between intensity of colour and amount of sodium hydroxide added, distilled water with $(NH_4)_2SO_4$, 100 mg. N/ton was used. To 50 ml. samples 5 ml. salt seignette 30 % solution was added and afterwards varying amounts of sodium hydroxide solution and 1 ml. of Nessler's reagent.

Table 1.

Sample No.	ml. NaOH 20 %	Relative intensity of colour	Time of reaction
1	0·1	1·00	60 sec.
2	0·2	1·17	20 sec.
3	0·4	1·27	20 sec.
4	1·0	1·35	20 sec.
5	3·0	1·40	20 sec.

The results are presented in Figure 1, showing that the intensity of colour increases with the increasing amounts of added NaOH, approaching a maximum value at 3 ml. NaOH.

In the column on the right, Table 1, the time in seconds is recorded from the moment when the Nessler reagent was added to the moment when the colour intensity was measurable. With addition of as little as 0·1 ml. NaOH or less, the time of reaction was long. When more was added, the time of reaction was so short that the intensity could be measured immediately.

Experiments with varied amounts of salt seignette indicated no noticeable effect upon time of reaction or intensity of colour.

[1]) Sometimes known as Rochelle salt, i.e., potassium sodium tartrate.

Variation in intensity of colour with time was studied in two samples containing 100 mg. N/ton. To one of them 5 ml. salt seignette, 3 ml. sodium hydroxide, and 1 ml. Nessler reagent were added to 50 ml.

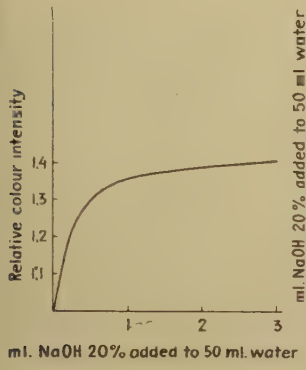

Figure 1.

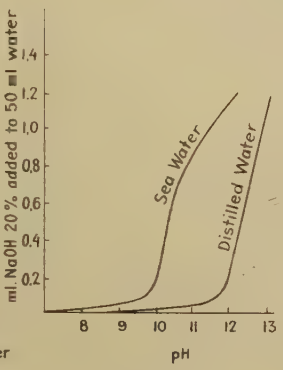

Figure 2.

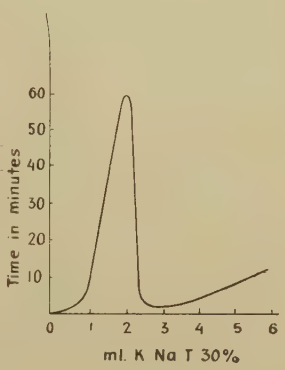

Figure 3.

water. After 15 minutes the same amount of reagents was added to the other and it was then analysed colorimetrically after 1, 2, 3, 5, 10, and 15 minutes, with the first one as standard. The results are recorded in Table 2, relative to the value after 15 minutes.

Table 2.

Time in minutes	Relative colour intensity	Time in minutes	Relative colour intensity
1	0·79	5	1·0
2	0·98	10	1·0
3	1·0	15	1·0

These experiments show that colour intensity as well as time of reaction depend upon pH. In order to obtain optimal conditions one must work at a pH corresponding to an addition of 0·5 ml. NaOH 20 % to distilled water. Sea water, having a considerable buffer capacity, needs other amounts of NaOH to obtain the same pH. Figure 2 shows changes in pH with varying amounts of NaOH added to distilled water and sea water, both samples being provided with 5 ml. salt seignette to 50 ml. water.

The sea water which was used was a mixture of samples from different parts of the Oslofjord. The curves show that an addition of 1—2 ml. NaOH to 50 ml. sea water is sufficient to obtain a pH giving a rate of reaction so high that optimal conditions prevail (cf. Fig. 1).

The second problem, to find means of retarding the precipitation of hydroxide, always occurring when sea water is made highly alkaline, was studied by varying the amounts of salt seignette added. To 50 ml. sea water (a mixture of samples from the Oslofjord) salt seignette in

varying quantities was added, followed by 3 ml. NaOH and 1 ml. Nessler's reagent. The time from the addition of the reagent to the occurrence of noticeable turbidity was recorded (Table 3).

Table 3.

ml. salt seignette 30 %	Time, in minutes, before turbidity was observed	ml. salt seignette 30 %	Time, in minutes, before turbidity was observed
6	13	2	60
5	7	1·5	33
4	3·5	1	11
3	1·0	0·75	0
2·5	1·5	0	0

A very surprising and distinct maximum in the time elapsing before turbidity is noticeable occurs when 1—2 ml. salt seignette is added (Fig. 3). This maximum would change a little with salinity, and this would explain why Wattenberg, who used 2·5 ml. salt seignette 30 % solution, could obtain such good results with his 35 ‰ salinity sea-water samples, and Braarud and Klem with the same recipe such bad results with their sea-water samples of less salinity.

The experiments show that it is possible to modify Wattenberg's method in such a manner that it will work satisfactorily with the sea-water samples we have been using.

The following procedure was chosen:—

Reagents: A) Salt seignette solution 30 %
B) NaOH solution 20 %
C) 10 g. HgI_2 in 5·5 g KI and 20 g. NaOH dissolved to 100 ml.

To a water sample of 50 ml. were added 2 ml. A and 2 ml. B. Subsequent to the addition of 1 ml. C, the sample was analysed colorimetrically after 2 minutes and compared with a standard. As a check, 1 ml. of a known $(NH_4)_2SO_4$ solution was added after the fist analysis and the sample analysed again. This was repeated once more in order to have frequent control of the standard.

In accordance with this procedure a series of water samples from different localities and depths in the Oslofjord was analysed. The time elapsing before turbidity was observed varied from sample to sample, but in no case did turbidity occur so quickly as to interfere with the analysis.

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Observations sur deux Ammodytidés des Côtes Françaises, *Ammodytes lanceolatus* Lesauvage et *Ammodytes lancea* Cuvier.

Par

Jacques Forest.

LES Ammodytidés sont représentés dans les mers Européennes par un seul genre, *Ammodytes* Artedi, très largement distribué de la Mer Blanche à la Méditerranée.

Pendant longtemps, on en a admis 3 espèces: *Ammodytes cicerellus* Rafinesque, dont la dorsale et l'anale ont le bord ondulé et qui est dépourvu d'écailles; *Ammodytes lanceolatus* Lesauvage et *Ammodytes lancea* Cuvier (synonyme: *A. tobianus* L.), tous deux à dorsale et anale à bord rectiligne, mais différant l'un de l'autre par la présence, chez le premier seulement, de 2 dents vomériennes.

Des investigations récentes sur *Ammodytes lancea* dans les eaux Ecossaises (R a i t t 1934), Danoises (J e n s e n 1941), Baltiques (K ä n d l e r 1941), Norvégiennes (S o l e i m 1945) ont conduit à la fragmentation de l'espèce en plusieurs races ou sous-espèces, caractérisées par le nombre de vertèbres et de "plicae laterales" et par le nombre de rayons à la dorsale et à l'anale.

En France, les Ammodytidés sont connus sous les noms de "cicerelles" (*A. cicerellus*), "lançons" (*A. lanceolatus*), et "équilles" (*A. lancea*), ces deux derniers ayant souvent fait l'objet de confusions. Le genre n'y a pas été l'objet d'une révision récente.

En Avril 1947, nous avons examiné un lot de "lançons" pêchés sur la plage des Dames, à Douarnenez. Il s'agissait en fait d'un mélange, en proportions sensiblement égales, de lançons et d'équilles. La taille moyenne était à peu près la même dans les 2 espèces: 14·3 cm. pour les premiers, 14·35 cm. pour les seconds. Les lançons étaient des immatures, à écailles sans anneau d'hiver (Fig. 1), les équilles étaient des adultes (organes génitaux au stade II—III de H j o r t) à un anneau d'hiver (Fig. 2).

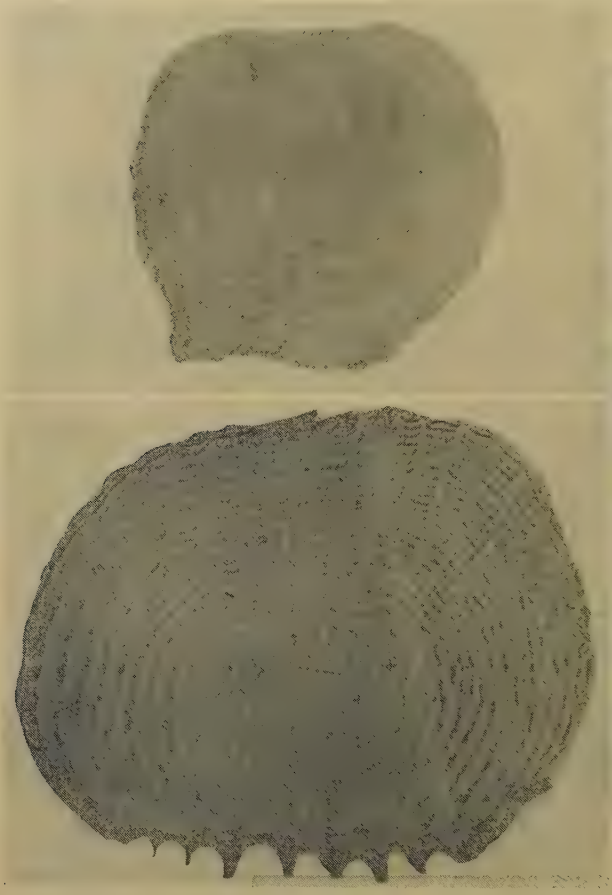

Figure 1 (en haut).
Ecaille d'*Ammodytes lanceolatus* (× 100).
Figure 2 (en bas).
Ecaille d'*Ammodytes lancea* (× 100).

Figure 3.
Otolithes d'*Ammodytes lanceolatus* (à gauche) et d'*Ammodytes lancea* (à droite).
Les otolithes de chaque paire appartiennent à des poissons de même taille. (× 10).

Nos résultats peuvent être ainsi résumés:—

	Ammodytes lanceolatus	*A. lancea*
Nombre de vertèbres	70 à 74	62 à 66
Mode	72	63
Moyenne	72·09	63·47
$n =$	78	91
σ	$\pm$0·90	$\pm$0·89
Fluctuations de la moyenne	$\pm$0·34	$\pm$0·32

Chez *A. lancea* la moyenne a également été calculée séparément pour chaque sexe. La différence est faible: mâles, 63·42, et femelles, 63·50.

En se rapportant à J e n s e n qui répartit *A. lancea* en 3 sous-espèces: *A. lancea lancea* Cuvier (60 à 66 vertèbres), *A. lancea marinus* Raitt

(66 à 73 vertèbres), *A. lancea dubius* Reinhardt (73 à 78 vertèbres), il conviendrait de ranger nos équilles dans la première.

La comparaison des proportions du corps a porté sur 30 lançons (taille moyenne: 14·35 cm.) et 26 équilles (taille moyenne: 14·15 cm.). Les caractères suivants ont été retenus:—

PO: distance de l'extrémité de la machoire inférieure au bord postérieur de l'oeil; L*cpl* longueur de la tête; P: distance de l'extrémité de la machoire inférieure à la pointe de la pectorale; D: distance prédorsale; A: distance préanale.

Chaque dimension a été exprimée en pourcentage de la taille, c'est à dire que les nombres qui figurent ci-dessous représentent les valeurs des rapports: $\frac{100 \times \text{Distance considérée}}{\text{Taille moyenne}}$

	PO	L*cpl*	P	D	A
A. lanceolatus:	10·3	21	28·1	27·7	56·8
A. lancea:	9·16	19·1	27·35	24·55	59

Nous en retiendrons particulièrement que la tête est plus longue et que l'anus occupe une position plus antérieure chez le lançon que chez l'équille.

D'autre part, la position de la pointe de la pectorale par rapport à l'origine de la dorsale a été fréquemment utilisée dans la diagnose des Ammodytidés. Il ressort du détail de nos mensurations que la dorsale commence: chez *A. lancea,* toujours nettement en avant de la pointe de la pectorale; chez *A. lanceolatus,* le plus souvent en avant de la pointe de la pectorale, quelquefois au dessus ou un peu en arrière.

Pour *A. lancea* nos résultats concordent avec les descriptions antérieures; pour *A. lanceolatus,* par contre, nous nous trouvons en contradiction avec les auteurs, en particulier avec Day, Moreau, Fage, Mohr, qui font commencer la dorsale au dessus ou en arrière de l'extrémité de la pectorale. Cette contradiction n'est peut-être qu'apparente et liée au fait que les lançons décrits par les auteurs cités plus haut étaient sans doute des adultes alors que les nôtres sont des immatures.

Il peut être plus aisé de distinguer *Ammodytes lanceolatus* d'*A. lancea* par la forme des otolithes que par l'aspect général du corps (Fig. 3). Tous deux ont une sagitta de forme elliptique, mais plus allongée chez l'un que chez l'autre. La différence peut s'exprimer numériquement par le rapport: longueur/largeur de l'otolithe, pour lequel nous avons trouvé les valeurs limites suivantes, en opérant sur 10 poissons de chaque espèce:—

Ammodytes lanceolatus: $L/l = 2{\cdot}12$ à $2{\cdot}37$ (Moyenne 2·27)
Ammodytes lancea: $L/l = 1{\cdot}76$ à $1{\cdot}95$ (Moyenne 1·86)

c'est à dire que la largeur de la sagitta est comprise plus de deux fois dans sa longueur chez *A. lanceolatus,* et moins de deux fois chez *A. lancea.*

Les Caractéristiques Morphologiques des Anchois (*Engraulis encrasicholus* Linn.) du Maroc.

Par

Jean Furnestin et **René Coupe.**

LES caractéristiques morphologiques des anchois du Maroc ont été déterminées d'après l'étude de 958 individus dont 446 de Casablanca, 106 de Safi, 93 de Mogador, 313 d'Agadir.

1. Taille.

Au cours des divers mois de l'année 1948 les tailles observées s'échelonnaient entre 5 cm. et 15 cm.

2. Répartition des sexes.

	Casablanca		Safi		Mogador		Agadir	
	♂	♀	♂	♀	♂	♀	♀	♂
Nombre d'individus	213	233	42	49	32	60	154	135
Pourcentage	47·8	52·2	46·1	53·9	34·8	65·2	53·3	46·7

Dans l'ensemble les femelles semblent plus nombreuses que les mâles, mais le pourcentage peut être inversé d'un lot à l'autre.

3. Caractère vertébral.

	Casablanca		Safi		Mogador	
	♂	♀	♂	♀	♂	♀
Nombre d'individus	212	232	41	49	31	60
Moyenne vertébrale	45·46	45·57	45·44	45·49	45·55	45·78

	Agadir		Total	
	♂	♀	♂	♀
Nombre d'individus	150	133	434	474
Moyenne vertébrale	45·44	45·48	45·43	45·56

1.) Les femelles dans tous les secteurs du Maroc présentent une moyenne vertébrale plus forte que les mâles. Cette différence, assez sensible, est remarquable car les espèces chez lesquelles une telle variation sexuelle se rencontre sont fort rares. Elle paraît cependant être de règle chez l'anchois puisque l'un de nous l'avait déjà constaté chez l'anchois du Golfe de Gascogne et que Lo Giudice l'avait aussi remarquée pour l'anchois des côtes Italiennes.

2.) Sauf dans le secteur de Mogador où les anchois étudiés provenant de pêches au chalut par profondeur de 100 mètres ont une moyenne vertébrale plus élevée, partout, de Casablanca à Safi et Agadir la moyenne est sensiblement de même valeur. La formule vertébrale de l'anchois Marocain peut être définie d'après 947 individus par les chiffres suivants:—

Nombre de vertèbres	43	44	45	46	47
Fréquences	1	25	**442**	**444**	35

Total	Moyenne	σ	*Flm*
947	45·514	± 0·61	± 0·06

Ces fréquences et cette moyenne sont de beaucoup inférieures à celles des anchois du Golfe de Gascogne (Furnestin[1]) 47·108 ± 0·09) et assez voisines de celles de la Méditerranée (Fage 45·76 ± 0·27).

4. Rayons de la nageoire dorsale.

Nombre de rayons	13	14	15	16	Total	Moyenne
♂	—	142	**261**	18	421	14·706
♀	2	141	**291**	27	461	14·745
Sexe indéterminé	—	15	20	—	35	—
Total	2	298	**572**	45	917	14·720

σ ± 0·55 *Flm* ± 0·06

Cette formule est plus faible chez l'anchois Marocain que chez celui du Golfe de Gascogne (14·96 ± 0·10) et comme chez ce dernier elle est un peu plus forte chez la femelle que chez le mâle.

[1]) Furnestin, J. Rev. Trav. Off. Sci. Tech. Pêches, T. XIII, fasc. 1—4.

Les proportions du corps. — Elles ne présentent que peu de variations suivant le sexe. Par contre les variations suivant la taille, donc l'âge, sont fortes.

5. Longueur relative de la tête $\left(\frac{100\,T}{LT}\right)$

Valeur de $\frac{100\,T}{LT}$

Taille en cm.	♂	♀	Moyenne (N=955)
7	22·97	22·86	22·92
8	22·81	22·87	22·83
9	22·70	22·49	22·57
10	22·85	22·88	22·85
11	22·75	22·80	22·78
12	22·74	22·65	22·69
13	21·60	22·26	22·10

La longueur relative de la tête décroît à mesure que la taille augmente. L'anchois Marocain a la tête plus longue que l'anchois du Golfe de Gascogne.

6. Distance prédorsale $\left(\frac{100\,D}{LT}\right)$

Valeur de $\frac{100\,D}{LT}$

♂	♀	Moyenne
42·09	41·94	41·96
41·80	41·56	41·67
42·11	42·24	42·16
42·18	42·13	42·17
42·21	42·40	42·31
42·83	42·82	42·82
43·10	43·11	43·11

La distance prédorsale croît avec la taille.

7. Distance préanale $\left(\frac{100\,A}{LT}\right)$

Valeur de $\frac{100\,A}{LT}$

♂	♀	Moyenne
52·79	52·88	52·84
53·79	53·77	53·78
53·92	54·12	54·03
54·49	54·43	54·47
54·64	55·11	55·09
55·21	55·44	55·33
55·90	56·18	56·13

La distance préanale augmente avec la taille et est légèrement plus grande chez les femelles que chez les mâles.

8. Conclusions.

Les données qui précèdent font ressortir que l'anchois du Maroc se sépare par ses caractéristiques morphologiques et surtout par sa formule vertébrale des autres groupements Atlantiques. On peut le considérer comme constituant une race différente des races Européennes.

Par ailleurs, nos chiffres mettent en évidence pour tous les caractères et plus particulièrement pour la formule vertébrale un très net dimorphisme sexuel.

A Cheek Tag for Marking Fish, with Semi-Automatic Pliers for Application of Tag.

By

Louella E. Cable,
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Introduction.

Many fishes, especially the anadromous fishes, travel long distances during their seasonal migrations. In order to study the life history and habits of such fish, it is necessary to trace the routes travelled throughout the life cycle of each species. Markers, or tags, are indispensable for the identification of individual fish as they pass from one locality to another, or reappear in a locality after an interval of absence.

The tagging and subsequent recapture of fish, to obtain specific information about them, is a technique of comparatively recent origin and is not yet well worked out for all species. According to Rounsefell and Kask (1943)[1]), the early tagging of fish was chiefly a hobby of wealthy owners of riparian rights whose records are scattered and unsatisfactory; and the first really successful demonstration of the tagging method was made only 75 years ago by Charles G. Atkins of the U. S. Fish Commission, on Atlantic salmon at Bucksport, Maine, in 1873. Since then, many types of tags have been developed for attachment to various parts of the fish, including:— dorsal, caudal, and adipose fins, opercle and preopercle, maxillary and pre-maxillary, the interior of the body cavity, through the flesh of the back, and around the entire body, anterior to the dorsal fin or about the caudal peduncle.

The materials of which tags have been made are as diverse as tag designs. Silver, platinum, aluminium, copper, tin, nickel, monel metal, steel, steel plated with nickel, rubber, ebonite, vulcanite and red cellulose were used in the construction of one or more of the numerous tags previously devised for marking fish.

When the present study of the shad fishery of the Atlantic Coast of the United States was undertaken by the U. S. Fish and Wildlife Service

[1]) Rounsefell and Kask give a detailed history of the development of fish tags with 232 references covering the literature from 1873 to 1933. Tags are classified into 18 categories with line drawings of examples of each type.

in 1937, it was desirable to tag samples of shad from the spawning runs to determine routes of migration into bays and rivers and subsequent migrations at sea. Selection of a suitable tag was beset by difficulties. None of the tags described in the literature was entirely satisfactory for marking shad. Obstacles were encountered which do not seem to have seriously affected the results in tagging studies of other fishes.

Shad are caught by many small operators and marketed through a large number of local dealers, and transported by truck directly from point of landing to distant city markets or sold to consumers at the river bank. It is, therefore, impractical to use the internal metal tag which has been successfully detected in herring by the electromagnet. A tag of red cellulose acetate, inserted into the body cavity of migrating shad, gave returns comparable to other tags tried, but was not discovered until the fish were dressed by the retail dealer or the housewife. Often it was difficult or impossible to determine where and when these fish had been caught. For these reasons no internal tag is suitable for the study of shad problems.

An external Petersen-type tag was used in several early tagging experiments. This tag consisted of one cellulose acetate disk attached on either side of the fish by a nickel pin passed through the flesh just below the dorsal fin. As the flesh of shad is weak, these tags work out within a short time. Hence, this type and other external tags depending on the flesh for retention, are unsatisfactory for this species of fish in experiments of long duration.

In 1945, I designed the tag, of metal and plastic, described in the pages following, to provide a permanent external marker for shad caught and liberated at sea in order that the survivors might be recognized upon recapture either at sea or in the streams of their origin. The cheek was selected as the point of attachment because it is a stable part of the body, of thin bony structure, through which a sharp object can be passed with a minimum of injury to the fish. The cheek is so far forward that a part of the tag fitting its inner surface does not irritate the delicate gill membranes.

The tag is light in weight yet large enough to attract attention of persons handling the fish in nets, on boats, and in fish houses, strong enough to withstand any pull exerted by a struggling fish, non-toxic to the body tissues and non-corrosive in sea water.

I am happy for this opportunity to thank Richard E. Tiller and Ralph C. Hammer, who, in 1945, were biologists with the Maryland Department of Research and Education, for examination of the plans and for their encouragement. I wish also to express appreciation to George W. Glenn, former employee of the Fish and Wildlife Service, who made the first test tagging of shad in the field and pointed out shortcomings of an earlier model of the pliers; and to Douglas D. Moss, Aquatic Biologist, Connecticut State Board of Game and Fisheries, for reporting results of the use of the cheek tag on freshwater fishes.

Description of Tag.

General. The cheek tag (Figure 2, drawing C) is in the general category "bachelor button", defined by R o u n s e f e l l and K a s k (*loc. cit.*) as "Two disks or plates attached by a rigid shaft that pierces the tissues." Attachment of the tag to the cheek of the fish is accomplished with special long-jawed pliers (Figure 1, photograph A) that carry the rivet under the opercular flap to its position on the inner surface of the cheek.

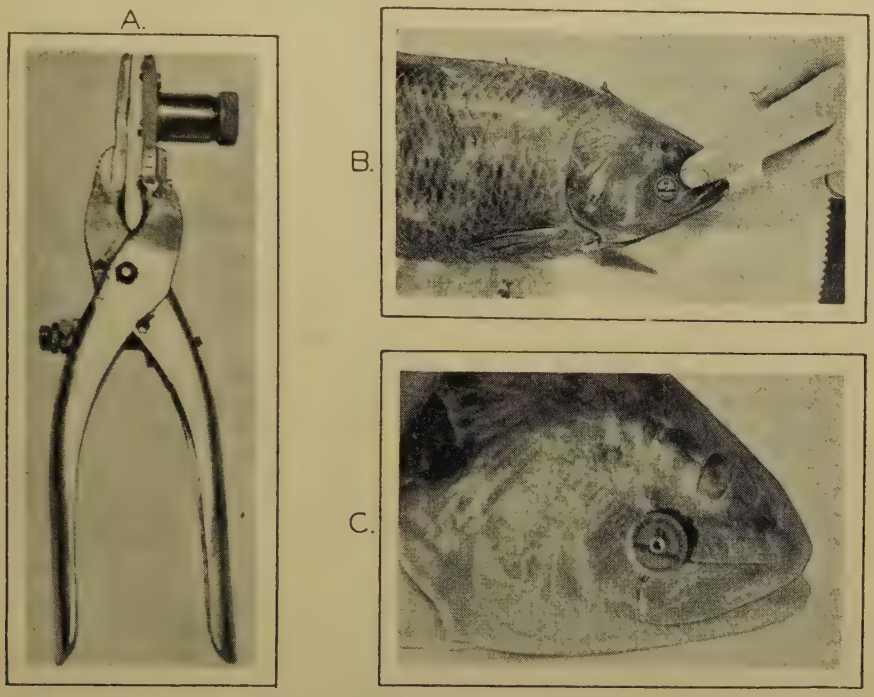

Figure 1. A. Semi-automatic pliers for attaching cheek tag. B. Cheek tag in place on fish. C. Enlargement to show relationship of tag on cheek to eye and maxillary.

Pressure applied to the handles forces the slender shank of the rivet through the cheek and clinches it firmly over an external disk of red cellulose acetate (Figure 1, photographs B and C).

Rivets. Much thought was given to selection of a metal for the rivet portion of the tag. First consideration was given to elimination of toxicity and, second, to hardness and weight of the metal used.

Dr. H. S. R a w d o n, Chief, Division of Metallurgy at the U. S. Bureau of Standards, considers monel metal "slightly better" than other metals[1]) for tags because it is less corrosive in sea water. For the same

[1]) William C. Herrington (by letter) stated that "commercial grade aluminium does not stand up uniformly well when used as fish tags". In his experience some lots were satisfactory while others corroded badly. Dr. Rawdon indicated that some aluminium alloys are less corrosive than the commercial grade.

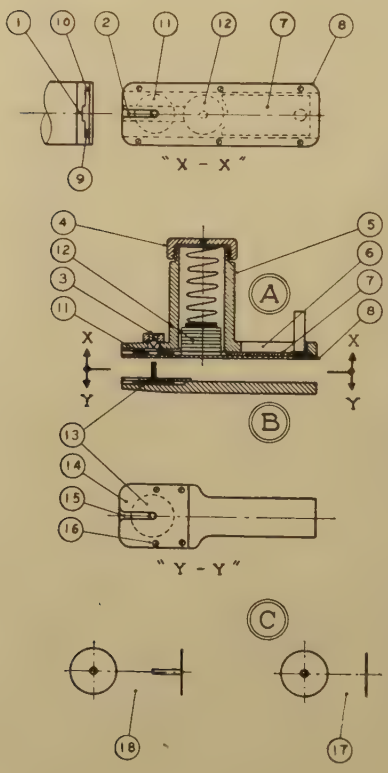

Figure 2. Detail of jaws of semi-automatic cheek-tag pliers.
A. Upper jaw. Contains magazine. 1. Groove in lower side of magazine to facilitate removal of crimped end of rivet over tag disk. 2. Slot for passage of shank of rivet. 3. Adjustable crimping pin. 4. Screw cup with spring attached. 5. Magazine to hold 25 tag disks. 6. Groove just long enough to permit tag disk to be pushed into position to receive the rivet. 7. Pusher with knob to be operated manually. 8. Lower plate of magazine part attached with screws so that it may be removed for cleaning. 9. Under side of magazine part with groove in which pusher and disks slide. 10. Flange, depth of tag disks. 11. Disk in position for crimping. 12. Position of disk in magazine.
B. Lower jaw. 13. Position of rivet C in rivet chamber. 14. Cover plate, which holds rivet in place, is attached with screws so that it may be removed for cleaning. 15. V-shaped notch to accomodate shank of rivet. 16. Hole for attachment.
C. Cheek tag. 17. Cellulose acetate disk. 18. Stainless-steel rivet.

reason it is more durable and less toxic. Stainless steel was given a high rating along with nickel and aluminium alloys.

Because of their great strength, metal disks may be very thin. The weight of the tag, therefore, is negligible in comparison to the weight of the fish and is insufficient to upset its equilibrium.

The rivets for the shad studies (Figure 2, drawing C-18) are machined of stainless steel U.S.S. 18-8. The round head is ·032 inch thick and $\frac{1}{2}$ inch in diameter. The outer and inner edges of the rim are smoothly rounded. The shank is $\frac{5}{16}$ inch long and ·062 inch in diameter, with a depression in the end $\frac{3}{32}$ inch deep and ·050 inch in diameter, leaving a ·006 inch thick side wall to form a flange when clinched. These measurements may be modified to meet specific requirements of special studies on shad and other species of fish.

Stainless steel and all metals suitable for fish tags are made in a wide range of hardness. Soft grades lack strength; while very hard grades are too brittle. An intermediate grade is most satisfactory.

Disk. The external disk (Figure 2, drawing C-17), held in place on the cheek by the rivet described above, is of red cellulose acetate, $\frac{1}{15}$ inch thick and $\frac{1}{2}$ inch in diameter with a ·07 inch hole in the centre.

It is brightly coloured, to be conspicuous in appearance for ready detection by fish handlers. The cellulose disks are serially numbered and carry printed instructions for the return of the tag with six scales for a $ 1·00 reward. The number, since it is of no interest to the finder of the tag, is printed on the side of the tag next the cheek and instructions face outward.

Description of Semi-Automatic Pliers.

Details of pliers needed for the application of the cheek tag are shown in Figure 2. The upper jaw (A) consists of a chamber (5) which holds about 25 of the external cellulose disks which may be fed into the clinching chamber (11) one at a time by the pusher (7) operated by thumbing the attached knob forward the full length of the groove (6). The adjustable crimping pin (3) spreads the hollow end of the shank of the rivet after it is forced through the cheek of the fish and passed through the hole in the centre of the external disk. A thin lower plate (8) provides a smooth surface on which to slide the disks and a terminal notch to guide the rivet toward the crimping pin and permit the pliers being withdrawn after the tag is secured.

The lower jaw of the pliers (B) provides a shallow chamber (13) just wide enough to take the disk-like head of the rivet. The notch in the cover plate for this chamber is V-shaped. It was found that rivets could be loaded into the chamber with greater facility, especially with cold-numbed fingers, when the notch was smoothly rounded instead of angular at its terminal end.

Stainless steel was used for the jaws of the pliers, and the handles, of rolled steel, are nickel plated to prevent rusting in salt water.

Technique of Tagging.

The success of tagging depends upon the rapidity with which the fish are handled. The process of tagging begins when a school of fish is gathered into a net which is drawn into a pocket to hold them alongside a boat while a few at a time are transferred by dip net to tubs of water on board to await their turn to be tagged. Very shortly after transfer each fish is caught up in the hands and arms of a person who holds it still while the tag is put on by another operator, or he may put the fish into a tagging trough where the length measurement may be taken and a scale sample removed while the tag is being attached. The length of time a fish may be out of water is short, so the operators must work fast to ensure good survival. The cheek tag may be affixed in two to three seconds after the fish is in position. The lower jaw of the pliers, with rivet, is inserted under the opercle to position inside the cheek with one movement; the rivet is clinched and the pliers are withdrawn with a second movement. The tagged fish is immediately liberated over the side of the boat. The whole process from transfer of fish from the

holding net to liberation over the opposite side of the boat is usually accomplished in a little less than one minute. Speed is especially important when tagging fish whose scales are held loosely in the scale pockets, as in the case of shad and herring, because longer confinement in the holding net is accompanied by greater injury from loss of scales. The loss of large patches of scales decreases the fish's chances of survival whether or not it is tagged. For this reason only well-scaled fish should be selected for tagging. Janssen and Aplin (1945) observed that many sardines, *Sardinops caerulea* (Girard), also "lose scales to a greater or lesser extent incident to catching, transferring to the live box and handling while being tagged". Deaths, caused by loss of scales combined with other injuries, occurred among tagged and untagged sardines and began shortly after the fish were placed in live boxes and continued about six days, after which few others died.

Recovery of Tags.

Cheek tags on shad have been detected most often by the fishermen, who give detailed information about the type of gear employed, also the time and place where the recaptures were made. Curiosity regarding the length of time tagged, the distance travelled by the fish, and collection of the reward offered, are incentives that prompt the fishermen to return the tags to the headquarters of the investigation. Of 236 tagged shad liberated off Mt. Desert Island in the Gulf of Maine in August 1947, 21 were recaptured the following spring and summer in spawning runs into rivers from Georgia to New Brunswick, 8 to 11 months after release.

Condition of Fish.

The wound caused by insertion of the cheek tag appears to heal, under natural conditions, without serious infection. Not one fisherman, who has captured a shad bearing one of these tags, has reported any irritation of the tissues around it. The tag rivets returned have been bright and uncorroded after nearly a year at sea.

A few of the freshwater trout, tagged experimentally with the cheek tag and held in a concrete pool at the Leetown, West Virginia, fish hatchery for several months, did develop infections that resulted in enlargements of the hole made by the rivet. No such infections were observed, however, by Douglas D. Moss on fish tagged and liberated into streams in Connecticut by the State Board of Fisheries and Game. His statement follows:— "I have seen and examined many perch, pike and pickerel that were recaptured during our spring tagging experiment. Some had been tagged over a month and showed little, if any, sign of infection. Fish recaptured several days after tagging often showed some irritation in the form of an inflamed area around the rivet, but this seemed to have disappeared in less than a week. We believe that this tag and its application is far superior to anything previously tried."

Résumé.

Une marque, décrite ici sous le nom de "cheek-tag" (marque operculaire) répond à la nécessité d'un marquage extérieur permanent, utilisable pour l'alose et d'autres poissons à chair molle. La marque est fixée à l'opercule, en raison de la structure osseuse et de la faible mobilité relative de cette partie du corps; elle a été expérimentée avec succès sur différentes espèces de poissons d'eau douce aussi bien que sur l'alose.

La pose de cette marque, à l'aide de pinces spéciales, également décrites ici, est si simple et si facile que l'opération peut être accomplie en 2 ou 3 secondes.

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Investigations on the Baltic Cod.

By

F. Chrzan.

1. Material and methods.

a. Material.

These studies of the Baltic cod in the Gulf of Gdansk are based on material collected during 1947. The material was divided into two groups:—

1) from Gdansk Deep,

2) from the coastal area, including the inshore waters along the Hel Peninsula, the Gulf of Puck, and the main estuary of the Vistula.

A depth of about 60 m. was taken as the boundary between the two areas, Gdansk Deep being the region with depths over 60 m.

As a rule, in Gdansk Deep, the fishing was done by means of a cod trawl, with wings of 40 mm. mesh, and a cod-end mesh of 30—25 mm. A fairly large number of small cod (404 fish, 8 to 28 cm. long) was obtained with a sprat trawl, used on two occasions only.

In all, 47 collections covering the whole year were analysed; 32 from Gdansk Deep, and 15 from coastal waters. As a result of the freezing of the Gulf of Gdansk from January to March and difficulties in fishing in other areas, we were unable to obtain material from the coastal area in the first quarter of 1947. The material from Gdansk Deep in this period was scanty.

Table I gives the number and weight of fish (males and females separately) obtained from Gdansk Deep and the coastal areas, for successive quarters.

To the data given in Table I must be added the small fish caught with a sprat trawl in Gdansk Deep (22 individuals) and in the coastal waters (404 individuals) weighing together 23 kg.

The total material analysed consisted of 5396 fish, weighing 3366 kg.

Table I.

Months 1947	Gdansk Deep ♂♂ Numbers	Gdansk Deep ♂♂ Weight in kg.	Gdansk Deep ♀♀ Numbers	Gdansk Deep ♀♀ Weight in kg.	Coastal areas ♂♂ Numbers	Coastal areas ♂♂ Weight in kg.	Coastal areas ♀♀ Numbers	Coastal areas ♀♀ Weight in kg.
1—3	318	219·2	312	342·4	—	—	—	—
4—6	878	524·8	348	415·3	145	61·9	198	109·4
7—9	801	437·5	417	305·7	144	71·1	224	119·9
10—12	363	233·2	238	195·3	295	144·9	288	163·3
Total	2360	1414·7	1315	1258·7	584	277·9	710	392·6

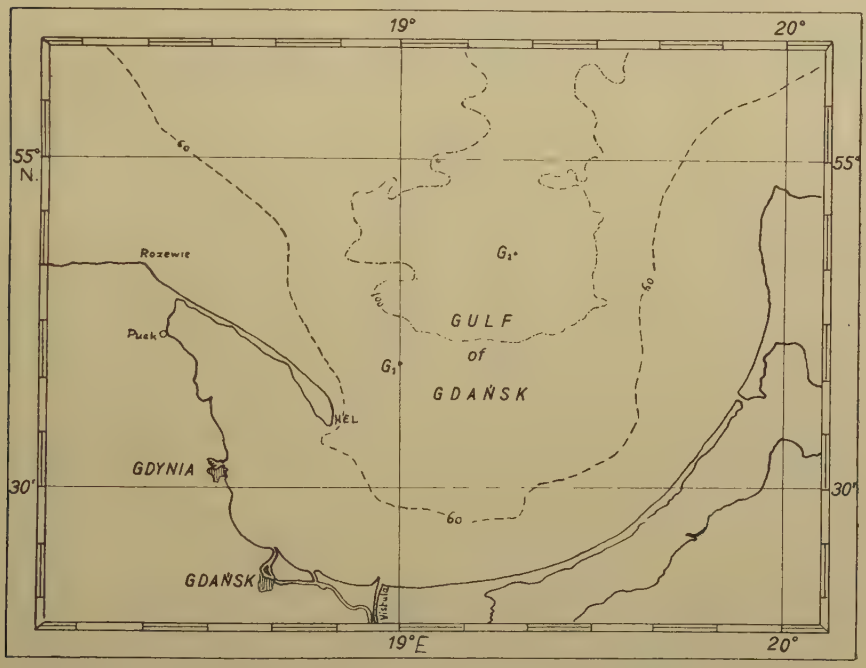

Fig. 1. Chart showing the locality of the investigations. Depths are in metres.

b. Methods employed.

In the analysis of the material, the following characters of the fish were considered:— length, weight of body, sex, degree of maturity of the gonads, and age.

The maturity stage of the gonads was defined according to Maier's scale. In doubtful cases the determination of the maturity stage was controlled by the weight of gonads expressed as a percentage of the body weight.

The age of the fish was estimated from the otoliths. In many cases in which age estimation was very difficult the rings of the otoliths were compared with those on the scales, or they were measured by means of

an eye-piece micrometer. Fish with otoliths of doubtful interpretation were disregarded (about 5 %).

In addition to these analyses, market measurements of the fish landed were made; 11,369 cod were so treated in 1947.

2. The ripening of the gonads.

The weight of the gonads expressed as a percentage of body weight is given in Table II.

Table II.

Degree of maturity of gonads	Percentage of body weight	
	Males	Females
I	below—0·5	below—0·8
II	0·5—4·5	0·8—5·0
III	2·5—6·5	2·5—12·5
IV	4·5—10·5	6·0—14·5
V	6·5—13·0	9·5—28·0
VI	13·0—6·5	28·0—14·0
VII	6·5—1·0	14·0—4·0
VIII	1·5—0·5	5·0—0·9

From Table II it is obvious that there are no definite limits to the weight of the gonads in successive stages of maturity. Their weight in relation to body weight is subject to great variations. This fact is dependent on a series of different factors such as age of fish, condition of nutrition, and genetic features. It is necessary to add that the figures presented in Table II apply to cases which are most frequently met. There are individuals of which the gonads differ considerably in comparison with the data given.

There are, for example, females the gonads of which amount to as much as 35 % of the body weight at the highest stage of development. On the average, the greatest weight of the gonads of females in stages V and VI amounts to as much as 28 % of the body weight; for males, 13 %. After the highest stage, and the expulsion of the sexual products, the weight of the gonads decreases, reaching its minimum at stage VIII.

The maturity cycle of the gonads in cod from Gdansk Deep is shown in Table III and Figure 2. The percentage numbers of individuals appearing in catches of different maturity stages were estimated from samples examined in successive months. The diagram illustrates the values given in Table III.

In the following discussion of the occurrence of fish in different stages of maturity, the data relating to the catches from coastal waters are also taken into consideration.

The young fish with gonads in stage I are found during the greater part of the year, with the exception of the period from May to August. However, in Gdansk Deep, they constitute only a small percentage of the total cod population. Their numbers in the catches increase only when in autumn and winter, the majority of the cutters work in Hel

coastal areas, and this region may be called the margin of Gdansk Deep. At this season, as Table III shows, the number of fish at stage I may amount to 6·5 % of the total catch.

Perceptibly greater numbers of individuals at stage I of gonad maturity are met with in the catches in coastal waters. In some cases they amount to as much as 13 % in the cod nets and still more in the herring or sprat nets.

In the deeper waters, cod in maturity stage II appear from September to April; they are most abundant, however, in November and December and then exceed 60 % of the fish caught.

Stage II fish are met with all the year round in the coastal waters. They are most abundant in the autumn months, due to the fact that in this period the young maturing individuals are joined by older fish returning from Gdansk Deep after spawning. In October fish in stage II amount to over 80 % of the total catch in this area.

Table III. Percentage of cod at different maturity stages in samples from the Gdansk Deep region.

Months 1947	♂ ♀	Stage of gonad development I	II	III	IV	V	VI	VII	VIII	Total
January	♂	1·89	15·91	17·43	13·26	1·89	—	—	—	50·38
	♀	3·03	26·52	14·77	5·30	—	—	—	—	49·62
February	♂	—	17·86	25·00	15·47	1·19	—	—	—	59·52
	♀	—	20·24	20·24	—	—	—	—	—	40·48
March	♂	0·34	3·07	16·72	20·14	6·83	—	—	—	47·10
	♀	—	13·31	17·41	13·65	8·53	—	—	—	52·90
April	♂	—	3·33	2·50	17·78	27·22	2·78	0·28	—	53·89
	♀	0·28	7·22	3·33	11·95	21·67	1·67	—	—	46·11
May	♂	—	—	—	2·91	22·65	43·72	13·90	1·12	84·30
	♀	—	0·22	—	1·35	7·17	6·50	0·45	—	15·70
June	♂	—	—	—	—	1·43	32·86	35·95	3·10	73·33
	♀	—	0·24	—	—	5·48	18·09	2·86	—	26·67
July	♂	—	—	—	—	1·16	25·19	42·17	4·83	73·31
	♀	—	—	—	0·39	6·00	17·41	2·51	0·39	26·69
August	♂	—	—	—	—	—	14·79	46·51	4·03	65·32
	♀	—	—	—	0·27	4·57	18·28	7·80	3·76	34·68
September	♂	0·61	0·61	—	—	—	9·69	37·88	5·15	53·94
	♀	0·30	13·64	—	—	2·73	15·15	3·03	11·21	46·06
October	♂	—	4·95	0·50	—	—	1·98	29·21	17·33	53·96
	♀	—	21·29	—	0·50	3·47	5·94	1·98	12·87	46·04
November	♂	1·02	23·05	13·22	3·39	—	2·71	11·86	8·14	63·39
	♀	0·34	26·78	4·41	0·68	0·68	1·02	—	2·71	36·61
December	♂	4·76	35·24	9·52	7·62	2·86	—	—	3·81	63·81
	♀	1·90	26·67	6·67	—	—	—	—	0·95	36·19

Cod in maturity stage III begin to appear in October, and fish at this stage are still found in deep water as late as April, but the highest occurrence of this stage falls in the months from December to March. In this period cod in stage III amount to about 45 % of the total catch; this applies also to the catches in the coastal area.

Individuals with gonads in stage IV are found as early as November. They occur in the greatest numbers, however, in the period from January to April, with the maximum in March, when they amount to

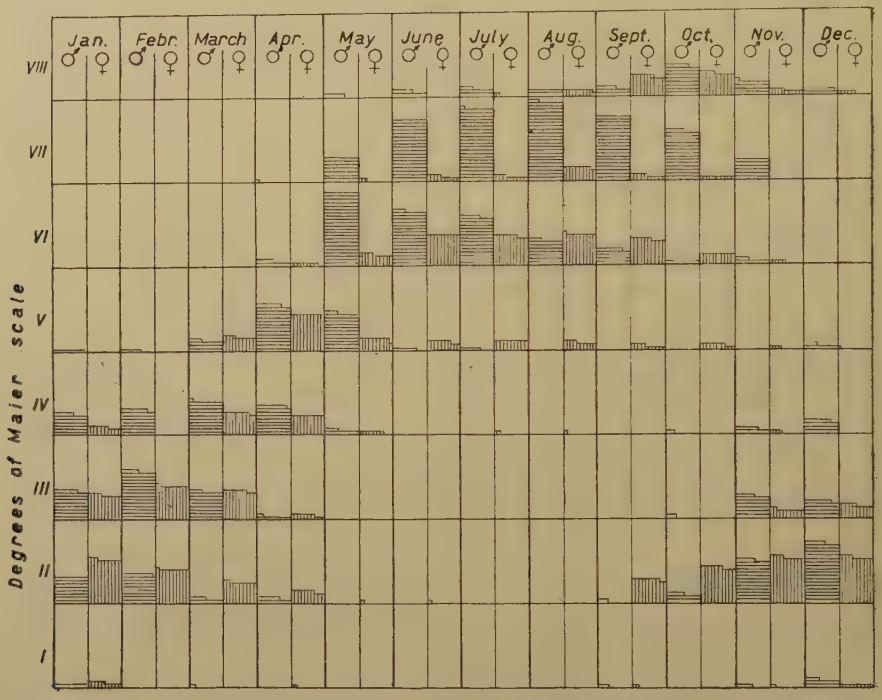

Fig. 2. Percentage of cod at different degrees of maturity in successive months in 1947, in catches from the deep water in the Gulf of Gdansk.

about 35 % of the total catch. The percentage of these cod in the coastal waters and on the margin of Gdansk Deep is about the same.

Fish at stage V are found all the year round in Gdansk Deep, but are most abundant just before and at the commencement of spawning, that is, in the months of April and May. The data on the composition of the coastal catches show that the fish in this stage leave the shallow coastal waters and gradually approach the spawning grounds. The males are the first to reach these grounds, which are situated in the middle of Gdansk Deep.

The females at the same stage tend to remain spread out along the route of migration, as is evidenced by the fact that the majority of them are found in the catches on the margin of Gdansk Deep. Only those

which are closely approaching maturity complete the migration to the spawning grounds.

Males in stage V are met with in the vicinity of the spawning ground from December to July; the females, on the other hand, from January or February to November. The earlier appearance of the males is to be explained primarily by the fact that the development of the gonads in the male precedes that in the female by about one month. The females do not travel to the spawning grounds until their gonads are almost mature.

3. The spawning of the cod in Gdansk Deep.

Fishing was begun after the disappearance of the ice, that is, on 25. March 1947. Our catches were made in Gdansk Deep in a region about 10—25 miles north-eastward of the point of Hel Peninsula. The depth of water in this region varies from 90 to 110 m. and the bottom is covered with a layer of mud.

The hydrographical conditions are given in Table IV (from unpublished data obtained by Miss A. Głowińska). The table shows the temperature, oxygen content, and salinity of the water at 80 m. depth on station G_1 (10 miles NE. from the point of Hel Peninsula) and at 90 m. depth on station G_2 (25 miles NE. from the point). In these depths, as Dr. Mankowski's and my own observations show, spawning is most intensive.

Table IV. Temperature, oxygen content, and salinity of the water in Gdansk Deep in 1947.

Date	Station G_1; 80 m.			Station G_2; 90 m.		
1947	Temp. °C	O_2 %	S ‰	Temp. °C.	O_2 %	S ‰
11.IV	—	—	—	5·00	29·23	10·84
9.V	4·85	39·76	10·52	4·90	30·49	10·93
29.V	4·20	41·71	10·01	2·80	66·36	11·46
1.VII	2·15	65·29	11·13	2·60	65·90	11·35
31.VII	2·10	63·61	11·09	—	—	—
5.VIII	—	—	—	2·80	51·71	11·44
14.VIII	2·15	58·85	11·46	3·35	71·58	12·32
13.IX	3·08	69·44	12·09	—	—	—
6.XII	6·87	60·95	12·30	5·40	54·23	12·54

It appears from Table IV that the cod spawn in water at a temperature below 5°C., when the oxygen saturation amounts to 30·5—71·5 % (mean saturation 55 %), and the salinity to about 11 ‰.

The progress of the spawning was followed by counting the numbers of running fish in the catches. In order to obtain a better survey of the spawning, the males and females in stages VI and VII (half-spent fish) were counted separately.

Observations made in previous years have shown that in Gdansk Deep the cod begin spawning in March or even in the latter part of February. In 1947 spawning did not begin till April and continued till

November. It seems that this retardation was due to the exceptionally hard winter of 1946/47.

It can be seen from Figure 3 that the percentage of spawning fish is very low in the second half of April and gradually increases to a maximum at the end of May. Examination of the sexes separately with regard to the state of the gonads leads to the conclusion that the first maximum relates to the males in stage VI. From the peak at the end of May, the number of males in stage VI decreases more or less steadily. At the end of September there are already very few males of this stage and their number continues to be small in the following months.

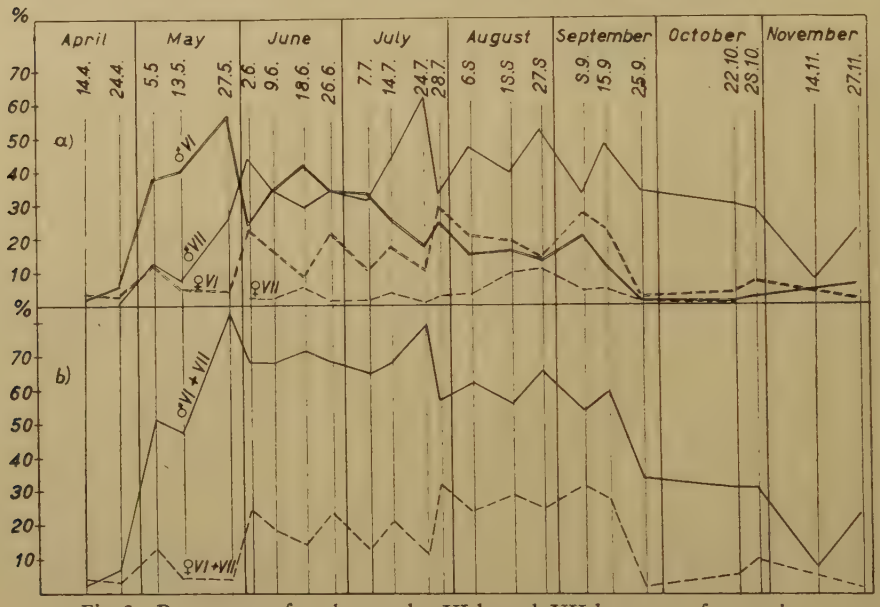

Fig. 3. Percentage of males at the VIth and VIIth stages of maturity during the spawning in Gdansk Deep.

Due to the expulsion of the sexual products, the gonads of the males diminish in size, and stage VI passes into stage VII. Nevertheless, males with gonads less than half the maximum weight still contain a certain amount of sperm. Such males predominate over a considerable part of the spawning period. Of course, before the end of the period, the amount of sperm is very small, since the weight of the testicle falls to 1 % of the body-weight.

The females do not appear in relatively large numbers on the spawning grounds until a month after the males. They number, however, considerably less than the males and do not show a proportionate increase until the second half of the spawning period.

In the whole population of spawning cod males in maturity stage VII constitute the greatest proportion. The proportion of females in the same stage is very small throughout the spawning period.

The relative numbers of male to female fish in the period of spawning are very characteristic. It can be seen from Figure 3b that, especially in the first part of the spawning period, there is a decided excess of males. The proportion of females in the catches on the spawning grounds in May, June, and July hardly reaches 27 %.

This excess of males can be explained by the fact that firstly, considerably more males than females ripen in the second year of their life; secondly, the gonads of the males begin to mature much sooner; and thirdly, the females remain on the spawning grounds a very short time.

The males mature much earlier and reach the spawning grounds much sooner than the females. At the beginning of the spawning period the males expell a great deal of sperm, but later, in stage VII, the decrease in the weight of the testicles is much slower.

The females reach maturity a month later than the males and enter the spawning ground with well developed ovaries. They soon expell their eggs and after doing so, return to the feeding grounds at once. As evidence of this opinion may be stated the fact that the eggs in the ovaries in late stage VI are almost all ripe and that only very few females with ovaries in stage VII are found on the spawning ground.

Figure 3, a and b, shows an unusually extended spawning period for cod. The diagram does not allow any conclusions to be drawn as to the date of greatest intensity of spawning. A parallel analysis of samples from areas beyond the centre of the spawning ground would be helpful in this respect.

Analysis showed that the cod began spawning in Gdansk Deep in April over a relatively small area, about 100 m. deep. The spawning ground gradually increased, occupying by the end of June almost the whole of Gdansk Deep (as defined by the 60 m. isobath). In the second half of June and the first half of July, the spawning ground spread still further, and running females were found even in the Gulf of Puck in water about 40 m. deep. The proportion of running fish was very small and did not exceed 2 % of the fish examined.

The date at which running cod are found over the widest area may be considered as marking the culmination of the spawning. It corresponds to the moment at which the numbers of males with gonads in stages VI and VII are present on the spawning ground in about equal numbers and the proportion of running females approaches its highest level.

After this date, the spawning ground gradually contracts, until at the end of the season it occupies about the same area as at the beginning.

4. The composition of the stock of spawning cod.

Table V gives the length of spawning cod at different ages. These figures relate only to fish from Gdansk Deep (2484 individuals).

As Table V shows the numbers of spawning cod, as well as their length and age, certain information is obtainable from it not only as to the number of age-groups, but to a certain extent also as to the growth of each age-group.

Table V. Length and age of spawning cod (stage V, VI, VII and VI

Length in cm.	Number of fish in age-groups										
	II		III		IV		V		VI		T
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
27	3	—	—	—	—	—	—	—	—	—	
28	5	—	—	—	—	—	—	—	—	—	
29	9	—	—	—	—	—	—	—	—	—	
30	14	1	—	—	—	—	—	—	—	—	
31	28	2	1	1	—	—	—	—	—	—	
32	44	11	4	—	—	—	—	—	—	—	
33	53	18	9	2	—	—	—	—	—	—	
34	59	22	22	8	—	—	—	—	—	—	1
35	83	20	26	9	—	—	—	—	—	—	1
36	80	28	56	13	—	—	—	—	—	—	1
37	57	21	65	19	—	—	—	—	—	—	1
38	72	17	80	29	—	—	—	—	—	—	1
39	60	16	81	21	—	—	—	—	—	—	1
40	49	16	84	38	—	—	—	—	—	—	1
41	31	12	84	30	1	—	—	—	—	—	1
42	19	7	85	29	3	3	—	—	—	—	1
43	17	5	78	32	7	—	—	—	—	—	1
44	11	6	48	1	7	2	—	—	—	—	
45	11	3	51	21	6	13	—	—	—	—	1
46	4	3	28	11	5	2	—	—	—	—	
47	2	1	31	9	10	3	—	—	—	—	
48	—	—	15	6	8	5	—	—	—	—	
49	—	—	11	5	8	1	—	—	—	—	
50	—	—	7	11	8	9	—	—	—	—	
51	—	—	10	5	7	1	—	—	—	—	
52	—	—	7	10	11	3	—	—	—	—	
53	—	—	3	6	5	3	—	—	—	—	
54	—	—	4	4	3	4	—	—	—	—	
55	—	—	6	3	5	9	—	—	—	—	
56	—	—	2	—	4	5	—	—	—	—	
57	—	—	5	1	3	4	—	—	—	—	
58	—	—	4	1	3	7	—	—	—	—	
59	—	—	1	1	4	2	—	—	—	—	
60	—	—	—	—	7	7	—	1	—	—	
61	—	—	—	—	5	3	1	—	—	—	
62	—	—	—	—	3	4	—	2	—	—	
63	—	—	—	—	3	4	—	—	—	—	
64	—	—	—	—	2	5	—	—	—	—	
65	—	—	—	—	2	8	—	1	—	—	

ble V continued.

gth m.	Number of fish in age-groups										
	II		III		IV		V		VI		Total
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	
	—	—	—	—	1	4	—	—	—	—	5
	—	—	—	—	1	2	2	—	—	—	5
	—	—	—	—	1	2	1	1	—	—	5
	—	—	—	—	1	1	—	—	—	—	2
	—	—	—	—	—	1	1	3	—	—	5
	—	—	—	—	—	2	1	2	—	—	5
	—	—	—	—	—	1	1	2	—	—	4
	—	—	—	—	—	2	1	1	—	—	4
	—	—	—	—	—	—	—	3	—	—	3
	—	—	—	—	1	1	3	—	—	—	**5**
	—	—	—	—	—	—	—	3	—	—	3
	—	—	—	—	—	—	—	1	—	—	1
	—	—	—	—	—	—	1	2	—	—	3
	—	—	—	—	—	—	1	—	1	—	2
	—	—	—	—	—	—	—	1	—	2	3
	—	—	—	—	—	—	—	1	1	—	2
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	2	1	—	3
	—	—	—	—	—	—	1	1	—	1	3
	—	—	—	—	—	—	—	1	—	2	3
	—	—	—	—	—	—	1	—	—	1	2
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	1	—	—	1
	—	—	—	—	—	—	—	—	—	1	1
	—	—	—	—	—	—	—	—	—	3	3
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	1[1])	1
otal	711	209	908	340	135	123	15	29	3	10+1	2484
ean ngth	(35·4)	(37·1)	41·3	42·3	52·3	56·3	73·4	74·2	(81·0)	85·9	41·6

[1]) 7-year-old fish.

The two-year-old fish, that is, 37 % of the spawning cod, constitute probably only a very small proportion of the total two-year-old group, and are the fastest grown individuals of this age-group. We see that among them, males are decidedly predominant and mature females in age-group II are rare. This mean length of the spawning cod in age-group II cannot be considered as characteristic of the size of this group generally, since it applies only to the largest individuals.

Three-year-old fish predominate among all the age-groups represented on the spawning grounds. The fact that 50 % of spawning cod belong to the 3-year-old group would indicate that the cod from Gdansk Deep generally spawn at the age of about 3 years.

The mean length of the spawning three-year-old cod is rather more than 41 cm.; this length can be considered as characteristic of fish of age-group III.

The number of 4-year-old cod among the spawners is considerably smaller. Only 10 % of spawning cod in Gdansk Deep belong to this age-group. It might be thought that this is the second or third spawning in their life. There are reasons, however, to suppose that some individuals of this age-group are spawning for the first time. Catches from coastal waters sometimes contain individuals which have ended the third year of life, but which are still in an early stage of gonad development (I). As they do not exhibit any signs of sterility, it may be supposed that they reach maturity in the fourth year of life.

Four-year-old spawning cod show a length-range of 41 to 75 cm. The mean length of this age-group, about 54 cm., may, to a certain extent, be characteristic of the length of cod ending the fourth year of life.

The 5-, 6-, and 7-year-old cod hardly exceed 2 % of the total spawning population. As none of these age-groups is represented by more than few individuals, their mean lengths cannot give a precise idea of the rate of growth. Nevertheless, they indicate that the Gulf of Gdansk cod are fast-growing fish.

Individuals in any of these age-groups show great differences in length; 3-year-old males, for example, vary in length from 28 to 55 cm. Apart from the normal causes of individual variability, these differences can be best explained by the exceptionally long period of spawning. Individuals born at the beginning (March) and at the end of the spawning period (November) are classed as belonging to the same age-group, but in fact their ages, and consequently, their body lengths, differ greatly.

Beside the variations in length, variations in weight are also found among individuals of the same age-group. These variations are presented in Table VI, for particular groups.

Table VI. Weight of different age-groups of spawning cod.

Age of fish	2 years	3 years	4 years	5 years	6 years	7 years
Weight in g.	160-910	240-1900	470-4180	1760-6840	4140-9110	—
Mean weight in g.	358	630	1410	3664	5770	(11,200)

In considering the variations in weight, it is necessary to take into account the state of nourishment of the fish, the sex and condition of the gonads, and the length. Well nourished females, with well developed gonads and bound for the spawning ground, have the greatest weight, while the fish returning from spawning have the lowest weight. A comparison of the lengths of the males and females in each group shows no significant difference. The diagram, Figure 4, based on the data in Table V, illustrates the composition of the stock of spawning cod.

Fig. 4. Percentage of males and females in particular age-groups.

It appears from the diagram that the three-year-old males are most numerous on the spawning grounds. They constitute 36·56 % of the spawning fish.

The proportion of females to males is also interesting. In general this amounts to 1 : 3·5 in favour of the males. The ratios for the various age-groups are given in Table VII. The conditions in catches from coastal waters are quite different, for the ratio is 1 : 1, or a small excess of females may even occur.

Table VII. Proportion of males to females on the spawning grounds.

Age of fish	2 years	3 years	4 years	5 years	6 years	7 years
♂ : ♀	3·4 : 1	2·7 : 1	1·1 : 1	1 : 1·9	1 : 3·3	0 : 1

The distinct excess of males over females in the younger age-groups gradually disappears as age increases. In age-group IV the sexes occur in equal numbers, while in older age-groups there is an excess of females.

There is a certain advantage in such a state of affairs, in so far as the preservation of the stock is concerned. The intense fishing on the spawning grounds falls most heavily on the males, while the majority of the females survive. Next year they reappear on the spawning grounds as larger fish producing more eggs.

Among the spawning fish, those of 39 cm. in length are the most numerous. Table VIII gives the percentage frequency and weight of cod caught during spawning, for class intervals of 5 cm. of length.

From this table it might appear that the production of spawn would depend mainly on 3 length-groups, namely 31—45 cm., these being the most numerous. When studying the maturity stages, we noticed, however, that the size of the gonads and the quantity of sexual products

as a rule depend upon the weight of the individual fish. Therefore, in considering which of the length-groups are likely to dominate the spawning, weight must be taken into account. Examination of the percentage weights of the length-classes shows that the intensity of the spawning is decided by the larger individuals. Fish shorter than 36 cm. constitute 19·41 % of the spawning population, whereas by weight they account for only 9·34 %. Hence it can be stated that the fish which determine the spawning productivity are those from 35 to 45 cm. in length.

Table VIII. Percentage frequency and weight of different length-groups of running cod.

Length in cm.	Number %	Weight %
below 31	1·89	0·61
31—35	17·52	8·73
36—40	37·56	27·03
41—45	26·30	26·30
46—50	7·84	10·48
51—55	4·05	7·57
56—60	1·95	4·86
61—65	1·00	3·17
66—70	0·53	2·04
71—75	0·68	3·42
76—80	0·26	1·54
81—85	0·21	1·96
86—90	0·21	2·29

5. The commercial catches of cod.

The cod fishery does not take place in the same region all the year round. It moves successively away from the coastal waters towards Gdansk Deep and after spawning is over, it returns to the coastal waters. The fishery in the Gulf of Gdansk may be described from researches covering a full year, and divided into four 3-month periods.

As a rule, in the winter months, that is, in the first quarter of the year, fishing is almost entirely confined to coastal waters, as far as the edge of Gdansk Deep. Fish caught in this period are typical feeding specimens. Their stomachs are full of food consisting of Mysis, Pontoporeia, Mesidotea, Diastylis, and Polychaeta. The gonads of these fish are in stages II, III, and IV — with a small number in stage V, which are caught more towards the end of this quarter and in deeper waters. At the end of the first quarter migration towards the spawning ground in Gdansk Deep commences. The proportion of males to females is at first about 1 : 1, but begins to change at the end of the period.

The nearer to Gdansk Deep the more numerous the males become. The fishing in this period yields fish of good quality and is fairly productive (average catch, 3200 kg. per cutter/day). In 1947, however, catches were unusually small, since the fishing fleet was held in port by the freezing of a wide stretch of coastal water.

In the second quarter, the majority of the cutters fish in Gdansk Deep. The maturing fish leave the feeding grounds in coastal waters and make towards the spawning grounds. Less and less nourishment is found in the intestines of the fish caught, and in April their gonads are mostly in stage V. They mature, however, in a short time, so that the middle of Gdansk Deep becomes one great spawning ground. The fish appear in larger and larger shoals, and the area of the spawning ground gradually extends to its limits. The proportion of the sexes is distinguished by a decided predominance of males. None of the samples from catches in this period showed less than 70 % of males, and in some samples the proportion of males reached 90 %.

The fishery reached its peak in the second quarter of 1947 (average catch, 5300 kg. per cutter/day).

The coastal fishery becomes less productive in the spring months, since at this season the larger fish begin their migration to the spawning ground, while the immature fish are still too small to be worth fishing.

At the beginning of the third quarter of 1947, the catches on the spawning grounds began to grow smaller and the fishing gradually moved towards shallower waters, though some fishing on the spawning grounds was still going on at the end of this period. This movement of the fishery was caused by the diminution of the intensity of spawning and the movement of spent fish back towards land. At the end of summer the catches were very variable on the spawning grounds, as a result of the dispersal of the fish, and were on the whole less productive (average catch, 3000 kg. per cutter/day). More fish returning from the spawning grounds began to appear in the coastal waters, which accounts for the increasing yield from this area.

In the last quarter, when the fish feed very actively, the fishery once more approaches the coastal waters. After a transitional stage at the end of the spawning season, the very low yield (about 1600 kg. per cutter/day) gradually improves. This is due, in part, to the cessation of spawning and the return of the fish to their feeding grounds and also to the presence in the catches of a new age-group, which has now grown sufficiently to play a part in the fishery.

The Polish catches of cod in the Baltic amounted in 1937 to 1,732·7 tons, and in 1938 to 1,226·5 tons. After the war, the yield increased considerably. The monthly landings in 1947 are calculated in Table IX.

Table IX. Polish landings of cod from the Baltic in 1947.

Month	Tons	Month	Tons	Month	Tons
I	1,166·8	V	4,010·6	X	2,196·1
II	382·8	VI	3,713·4	XI	2,295·7
III	1,147·6	VII	2,003·4	XII	2,773·3
IV	3,672·5	VIII	2,240·9	Year	28,528·1
		IX	2,925·0		

It appears from Table IX that in 1947 the average monthly landings of cod were about twice the year's total for the whole of 1938. It is to

be emphasized that 83·4 % of the total catch of cod came from the region of Gdansk Deep.

Figure 5, which shows the percentage of fish at various lengths, is based on market measurements (11,369 cod were measured).

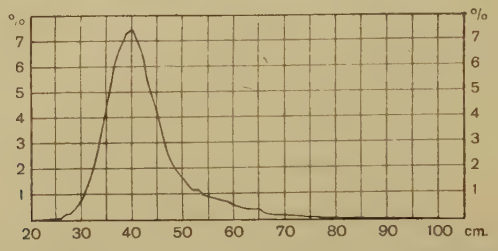

Fig. 5. Length composition of the catches of cod landed in Gdynia. Number of fish measured, 11,369.

According to these data, the modal length of the cod landed is 40 cm., and the mean length 42·3 cm.

The two following tables indicate the percentages of fish of different ages caught in Gdansk Deep and in coastal waters.

Table X. Percentage of different age-groups in the catches from Gdansk Deep in 1947.

Month	Age-Groups 0	I	II	III	IV	V	VI	VII
1—3	—	—	23·17	55·24	16·35	3·17	1·43	0·64
4—6	—	—	39·89	46·33	10·53	2·44	0·73	0·08
7—9	—	0·33	37·68	51·64	9·53	0·74	0·08	—
10—12	—	7·99	46·42	37·27	7·49	0·83	—	—

Table XI. Percentage of different age-groups in the catches from coastal waters in 1947.

Month	Age-Groups 0	I	II	III	IV	V	VI	VII
1—3				no data				
4—6	—	7·58	54·81	31·20	5·25	0·58	0·58	—
7—9	0·81	9·51	56·79	30·44	1·64	0·81	—	—
10—12	0·17	11·83	56·09	30·52	1·20	0·17	—	—

These tables show that the most important year-class in the catches from Gdansk Deep is that born about three years before being caught. It also appears that the proportion of the different age-groups in the catches varies through the year. The older classes decrease in number towards the end of the year. On the contrary, two-year-old fish appear in much greater numbers (46 %) in the last quarter. This year-class will decide the yield of the fishery in 1948.

In connexion with the appearance of the new age-group, the question is, what percentage of the catches is composed of fish which have not yet

spawned? The answer to this question seems to be as follows:— As a rule the cod first spawns in the second or third year of its life. A fish in stage VII was accepted as having fulfilled its task of reproduction and of maintaining the stock. The percentage of fish that had not yet spawned was estimated from the number of fish less than 3 years of age without spawning rings on the otoliths and with gonads in stage VI or earlier.

Table XII. Percentage of virgin fish caught in Gdansk Deep.

Month	I—III	IV—VI	VII—IX	X—XII
% of fish	65·2	64·0	34·5	37·0
% of weight	37·1	42·5	31·5	32·0

The fact that the intense fishery for cod in the Baltic over several years had no influence on the stock is probably due to the great reproductive capacity of this fish, as well as to the fact that females are caught on the spawning ground in a much smaller proportion than males.

Summary.

1) The male precedes the female in the maturity cycle by about one month.
2) The fish migrate to the spawning grounds in the deepest parts of the Gulf of Gdansk when they reach stage V.
3) The cod spawning season begins at the end of winter, reaches its peak at the end of spring, and draws to a close in November.
4) Males predominate on the spawning grounds. They constitute at least 70 % and even reach 90 % of the spawning population. This predominance is especially marked in the younger age-groups, whereas in the 5th and older age-groups the females predominate.
5) Cod in the Gulf of Gdansk as a rule spawn for the first time when about three years old. 87 % of the spawning cod examined were in this group.
6) The mean length of the spawning 3-year-old cod is 41 cm.; that of the 4-year-old fish, 54 cm.
7) During the spawning migration, the fish follow a variety of routes; as a result the fishery undergoes corresponding changes in location.
8) The yield of the cod fishery in Gdansk Deep after the war is many times greater than before the war.
9) The 3-year-old fish play the most important rôle in the fishery. A considerable proportion of the catch consists of fish which have never spawned.

Fluctuations in the Water and Fat Content of the Cod.

By

M. Bogucki and **P. Trzesinski.**

SEASONAL changes in the chemical composition of the cod were studied by determining the water and fat contents of the muscle tissue and the fat content of the liver.

The flesh and livers of 5 fish were used for each analysis. From the minced flesh or liver, samples were taken for the estimation of water and fat. The determination of fat was carried out by the Soxhlet method or by that of Bull.

The results are shown in Table 1, which gives the average water and fat content of the flesh and the fat content of the liver of the cod in successive months. No distinction was made between the sexes.

It may be remarked that the observed water content of the muscle tissue was never below 80 % of the total weight of muscle at any time of the year.

Figure 1 shows that the water content of the flesh reached its maximum in the spring and summer, between May and September. In this period the water content of the flesh frequently amounted to over 83 %. From September to April the water content of the flesh varied between 80·4 and 81·5 %. It is to be noted that analyses made in any one month exhibit considerable differences. For instance, on 5. November a water content of 80·7 % was found and on 19. November the figure obtained was 82·19 %. Such variations in water content are probably due to the different stages of sexual maturity at which the fish taken for analysis happened to be. According to Mankowski (1948) and Kändler (1938) the spawning period of the cod in the Gulf of Gdansk begins in March and lasts till November. The spawning ground is situated in the deep parts of the Gulf between the 60 and 100 m. isobaths, where the salinity of the water is over 10 ‰ and as much as 13 ‰ in the deepest parts; the temperature range there is very narrow — between 2° and 7°C. At the end of winter the cod migrate to the spawning ground and after spawning return to shallower water, where feeding, interrupted or reduced during spawning, is actively resumed.

The water content of the flesh of the cod is greatest in the spawning

period, when, according to C h r z a n, the fish are feeding very little or not at all and when the gonads reach their greatest development. The gonads in males may constitute as much as 14 % of the body-weight, and in females, 28 %.

As the fish in the sample were never in the same stage of sexual development, it is clear that the seasonal changes in the water content of the muscle tissue are much more variable than is shown by the diagram. Our figures give only the average values of the water content of the flesh of 5 fish.

Table 1.
Water and fat content of the muscles and liver.

Date	Water in muscles %	fat*) in muscles %	fat*) in liver %
1947			
19.VII	81·85	0·073	52·015
6.VIII	83·75	0·45	42·27
16.IX	81·65	0·105	48·64
22.X	81·00	0·225	49·93
12.XI	81·46	0·281	55·77
18.XII	81·50	0·054	48·25
1948			
14.I	80·39	0·052	63·54
13.II	81·18	0·064	65·60
16.III	81·08	0·177	67·77
8.IV	80·71	0·103	55·06
6.V	81·87	0·034	58·02
8.VI	82·97	0·306	45·57
9.VII	82·77	0·427	50·65
5.VIII	81·10	0·151	58·13
6.IX	83·56	0·254	39·36

[1]) Percentage of wet weight.

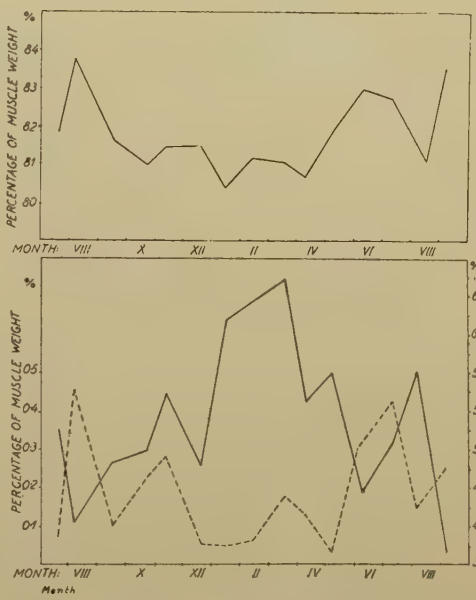

Fig. 1. (Top). Seasonal fluctuation of the water content of the muscles of cod.

Fig. 2. (Bottom). Seasonal fluctuations of the fat content of the muscles (- - -) and the liver of cod (———).

The same limitation applies to the determinations of the fat content of the flesh and liver. The amount of fat in the flesh is very small, varying during the year from 0·034 % to 0·45 % of the wet weight. The fluctuation in the fat content of the flesh is shown in Table 1 and Figure 2. Owing to the small quantities of fat and their great variation, the curve does not give us a very clear picture.

While the muscles of cod play, as has been shown, a very insignificant rôle as a store of fat, very large quantities of this substance are accumulated in the liver.

The liver of cod contains quantities of fat varying from 39 % to

68 % of its weight. The lowest values were found from June to September. In October there is a tendency for the percentage of fat in the liver to rise and the maximal fat content was reached in January—March (63—68 %). This last period in the seasonal life cycle of the Baltic cod is characterized by active feeding and the growth and maturation of the gonads.

In March spawning begins and the cod ceases feeding. The expenditure of energy during spawning and the very little food taken in this period result in the reduction of fat in the liver during the following months.

Assuming that the muscle tissue constitutes on an average 40 % of the body weight, with an average fat content of 0·16 %, and that the mean average weight of the liver per 1 kg. of the body weight is 43 g. with an average fat content of 53·5 %, we can calculate the amounts of fat in these two organs per 1 kg. of cod; the muscles will contain 0·64 g. of fat, the liver 23 g., i.e., 36 times as much as in the total mass of muscle. In the winter months, when the percentage of fat in the liver reaches nearly 68 % and the fat content of the muscles falls to about 0·05 %, the ratio of the amount of fat in the liver to that in the muscles can be over 100. It is therefore evident that the liver in the cod must be regarded as the principal depôt for the fat providing the energy expended by the cod during the spawning period.

Summary.

The results are described of analyses of the water and fat content of the muscle and of the fat content of the liver of the cod during successive months of the year.

The water content of the muscles is highest (83·5 %) in the period from May to September, and lowest (80·7 %) from September to April.

The fat content of the muscles varies from 0·034 % to 0·45 % of the muscle weight.

The fat content of the liver is highest (68 % of the liver weight) in the period preceding spawning (January—March), and is lowest at the end of spawning and in the period immediately after (June—September).

The average quantity of fat in the liver is about 36 times greater than that in the whole mass of the muscles.

The seasonal fluctuations of the fat content in the cod seem to depend on the progress of the fish's sexual activity.

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Factors Affecting the Survival of Fish Larvae.

By

Alf Dannevig and **Gunnar Dannevig.**

IN fish culture, the problem of the fry is of major importance. It is also of importance when studying the causes of the fluctuations in the strength of the year-classes.

The rearing of pelagic fry in the laboratory has been found difficult, and several opinions have been put forward as to the causes of failure. Thus the quality of the artificially hatched fry has been doubted. The successful rearing experiments of Rollefsen (1940) have shown, however, that large numbers of plaice fry are able to survive when fed with the larvae of *Artemia salina*. Successful rearing of *Solea solea* and *Pleuronectes microcephalus* has been carried out at Flødevigen by feeding the smaller fry with oyster larvae and the bigger ones with the larvae of *Artemia salina*.

As the fry grow, other food may be used, for instance, the flesh of *Mytilus edulis*, and with this as the main diet the young of *Solea solea* have been kept for three years, and are still alive.

Accordingly, the young of several species of flatfish may be reared in the laboratory provided they get sufficient and suitable food. Some species have, however, been more difficult to deal with, and we would like to draw attention to a few factors which have apparently given rise to some of the failures.

From several rearing experiments with cod and herring larvae it is evident that the gas content of the water is of great importance. At Flødevigen we have tried to rear cod larvae in aquaria in which the water was renewed once or twice a day. The water was taken from a large reservoir and introduced into the aquaria as soon as it had attained the same temperature as the "old" water. It often happened in these circumstances that very small gas bubbles were formed which attached themselves to the tiny fry. The fry developed white spots, curled up, and died.

In one experiment the cod larvae were kept in an aquarium of glazed earthenware in which the water was continuously renewed from the reservoir. The water was introduced at the top of the aquarium, and was let out through a sand filter in the bottom. On one occasion when the bottom was being cleaned by means of a siphon, the larvae suddenly turned upside down, came to the surface, and died in multitudes. On examining the dead fry immediately afterwards, they were found to be quite stiff, without external lesions, and with the *Artemia* larvae still alive in their stomachs. It is difficult to say what might be the real cause of the mortality, but while the siphon was in use some gas had escaped from the bottom, which perhaps brought up some toxic substances and very fine sand particles. The mortality had evidently something to do with this phenomenon; infection was out of question, as the fry died instantaneously. It is clear that this disaster must in some way or another have been due to the liberation of gas from the sea water.

At Flødevigen it has been observed that herring larvae kept in aquaria very often developed gas bubbles in the intestines. Such gas bubbles might also be found in the intestines of the fry of flatfish, but they generally succeeded in getting rid of them through the anus. This was not the case with the herring; after some time the herring larvae floated to the surface and died.

The occurrence of gas bubbles in the intestines of herring larvae has also been observed by Kotthaus (1939), Schack (1939), and Soleim (1940). Schack succeeded in rearing herring larvae until they had developed scales, by keeping the larvae under such conditions that no air bubbles occurred.

Several theories have been advanced to explain the accumulation of gas in the intestines of the larvae. At Flødevigen this phenomenon was clearly related to a supersaturation of the water with atmospheric gases. The fatal effect was eliminated by using water which had already lost most of its excess of gas. Before the water enters the aquaria it first passes through a sieve of very small-meshed silk net, on the outside of which the water forms a thin film. It also passes through a sand filter, in which large quantities of gas may accumulate. According to an analysis carried out by Ernst Føyn, at the Biological Laboratory, Oslo, this gas consisted of 22·5 % oxygen, the rest being nitrogen.

With this procedure it has in some cases been possible to rear a great number of herring larvae to a size of 20—30 mm., in some cases even to 50—100 mm. In other experiments, however, the mortality has for reasons unknown been severe under these conditions.

Sea water supersaturated with gas may also have a bad effect on older fish kept in the laboratory at Flødevigen. These often exhibit symptoms of "gas disease". Blisters filled with gas are formed in the eyes and in the skin, especially on the fins. In flatfish gas may also accumulate between the basal rays of the fins.

The gas disease in adult fish has been studied by Marsh and

Gorham (1905). They found that in fish dead from gas disease, the blood vessels always contained a quantity of free gas, mainly nitrogen. They therefore assumed that it is the excess of this particular gas which is most fatal.

They proved by experiment that if the fish were kept under pressure the symptoms of gas disease might be eliminated. Some observations at Flødevigen are of interest in this connexion. Fish living in the water reservoir, which is 4 m. deep, will generally not suffer from gas disease. But fish living under nearly atmospheric pressure in aquaria which get their water supply from the same pond often suffer from this complaint.

The use of water supersaturated with gas may therefore be the cause of much trouble encountered in biological experiments. In the present water-supply system at Flødevigen the water may become supersaturated with atmospheric gas in several ways. The effect of increased temperature is well known and need not be dealt with here. We will, however, draw attention to another factor which is related to the construction of the water-supply system.

The water is pumped by a centrifugal pump (1·5 m. above sea level) from a well ventilated fjord into the water reservoir, the top of which is 8·5 m. above sea level. The pump usually sucks air in through the shaft bearings. The result is that a continuous stream of air is injected into the water, which is under great pressure in the rising main, and a vast number of very small bubbles are formed in it. The water, which is under pressure until it enters the pond, may therefore absorb an excess of atmospheric gas during its passage through the rising main. In the water reservoir the surface water will tend to attain equilibrium with the atmosphere. The water in the deeper layers of the pond may, however, owing to the hydrostatic pressure, hold an excess of gas until it is brought to the surface through mixing processes, or allowed to flow into the aquaria.

In this connexion it should be mentioned that since the present water-supply system was built, it has been difficult to rear cod fry in the pond. Previously, good results were obtained by keeping the fry in a bag of silk net, kept floating in the pond by a frame of light wood. Into this bag there was a continuous flow of water taken from the main inlet to the pond, and the fry fed on the organisms in the water. At that time a slow-moving piston pump was used. There was only a short rising main just above the pump, and the water for the most part flowed under atmospheric pressure through open wooden conduits. Perhaps the slow-moving piston pump did not suck in so much air as does the present centrifugal pump; at all events the water had a better opportunity of attaining equilibrium with the atmosphere before reaching the pond. We would like to stress this point because similar rearing experiments in the pond after the water-supply system was rebuilt gave poor results. It seems as if the technical "improvements" have not been very favourable to the fry.

The elimination of excess gas has proved to be essential for the successful rearing of several species of fish larvae. But even in water which has been brought as far as possible into equilibrium with the atmosphere it is difficult to obtain good results with the fry of cod. Fed on *Artemia*, they may thrive well for a month or perhaps two, but then a heavy mortality usually occurs. The symptoms are generally the same. The larvae begin to turn on their side and grow pale, especially the anterior part of the body. Later they float to the surface and die. When examining the young we often found the air bladder distended with gas. The bladder sometimes burst, and the gas was seen as bubbles in the body cavity. Rollefsen has informed us that he had observed similar phenomena.

According to De Joung (1936) the air bladder of the cod is formed at a fairly early age. By the time the fish reaches a size of 6·5 mm. the *ductus pneumaticus* has disappeared. De Joung remarks that at this stage the nuclei of the cells in the gas gland have a peculiar appearance, and he therefore assumes that the air bladder has begun to function.

Very little is known about the function of the air bladder in very young fish. According to Leiner (1938) the air bladder is first filled by the fish swallowing air bubbles which subsequently pass through the *ductus pneumaticus*. This is said to take place also in fish in which this duct is later closed. In view of the small size of the cod fry, it is difficult to imagine that the air bladder really can be filled in such a way. It is more reasonable to assume that the first filling is effected by a liberation of gas from the gas gland, as in older fish. In cod fry kept in aquaria it is evident that the gas gland functions too actively in relation to the pressure under which the fry live.

It may be asked whether this apparent hyperfunctioning is due to special conditions in the aquaria. As far as our experience goes very little is known about the external and internal factors which regulate the action of this organ. Woodland has observed that when a small weight is attached to fish (pollack), the gas gland is stimulated to action whereas the "oval" contracts strongly. Thus the buoyancy of the fish influences the functioning of the air bladder in adult fish, but it is not known whether this is the case also with fry.

On the other hand the liberation of gas in the air bladder may be quite normal, the fatal effect being due to the fact that the fry are kept at too low a pressure when the gas gland begins to function. Fishing for pelagic fry in the Skagerak has shown that the cod larvae are most common at depths of 10 to 30 m. According to Wiborg (1938) this is also the case for the small cod larvae in Lofoten waters.

It has thus been shown by numerous experiments that the gas tension of the sea water has considerable bearing on the survival of several species of fish larvae. And, with the fry of cod, the factors which regulate and modify the operation of the air bladder are also of importance. These problems ought to be studied closely in nature as well as

in the laboratory. Experiments on the raising of cod larvae under high pressure would be very useful, but such experiments are certainly not easy to carry out.

As this paper is going to press, the results from the 1949 experiments are to hand. Besides herring and plaice, cod was also reared this year without any trouble. The surplus gas was largely eliminated by filtering the sea water through sand.

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Sur un Parr de Saumon Hermaphrodite parvenu à Maturité Sexuelle.

Par

M. Fontaine et **R. Vibert.**

I. Cycle génétique normal du Saumon atlantique (*Salmo salar* L.).

Le saumon atlantique, type des poissons migrateurs amphibiotiques, fraie en rivière, dans la zone à truite.

Le jeune, ou "parr", séjourne en rivière de 1 à 6 ans, rarement plus de 2 ans sous notre latitude. Après une mue qui lui fait prendre une livrée d'argent par dépôt de guanine sur les écailles, il est appelé "smolt" et descend à la mer en profitant en général d'une crue de printemps. Il pèse à ce moment près d'une quarantaine de grammes en moyenne pour l'Adour. Le séjour en mer peut durer de 15 mois à 3 ou 4 ans et même jusqu'à 5 ans dans les pays nordiques. Il revient alors, pesant de 1.5 kg. à 30 kg. et même davantage, remonte fleuves et rivières sur des centaines de kilomètres sans prendre aucune nourriture, pour alors seulement, aller pondre dans les hautes vallées, au début de l'hiver.

Pour les saumons de lac, ou "landlocked salmon" (*Salmo salar* variété Sebago) peuplant bon nombre de lacs de l'Amérique du Nord, côte atlantique, ainsi que les lacs Wenern et Siljan en Scandinavie, les lacs Ladoga et Onega en U.R.S.S., le cycle reste le même avec la différence que ce saumon, migrateur holobiotique, limite ses migrations à des déplacements entre ces grands lacs et leurs affluents.

Ce cycle normal comprend une exception, devenue classique à l'heure actuelle: le cycle pédogénétique du saumon mâle.

II. Cycle pédogénétique du saumon mâle.

Dès le XVIème siècle, ainsi que le note de Drouin de Bouville (1929), Bodenstein et Durge signalent l'intervention occasionnelle des parrs mâles dans la reproduction.

En 1686, Willughby signale que le *Salmolus,* c'est-à-dire aujourd'hui le saumon parr, fertilise les oeufs du saumon adulte. Il ajoute que le *Salmolus* femelle ne montre jamais d'oeufs mûrs.

En 1769, dans son "Traité général des Pesches" Duhamel du Monceau note à son tour que Artus a observé le même phénomène à Huningue sur le Rhin.

En 1868, Lablanchère indique que le fait a été signalé une cinquantaine d'années auparavant par Alléan Dulac dans un mémoire pour servir à l'Histoire Naturelle des Départements du Rhône et de la Savoie.

En 1840, Shaw précise qu'il a toujours observé sur les frayères de saumons:

1° — L'abondance de parrs mâles sexuellement mûrs.

2° — L'absence de parrs femelles.

3° — Le développement normal des alevins qu'il obtient par fécondation artificielle d'oeufs de saumon par la laitance des parrs.

Ces faits sont à nouveau observés par la suite par de nombreux auteurs, entre autres:

Yarrell en 1839; Brown en 1856 et 1862; Davy en 1855 et 1863; Widegren en 1864; Malmgren en 1863—1864; Russel en 1864; Rasch en 1857—1866; Murie en 1868—1870; Day en 1884, 1887 et 1888; Fritsch en 1893; Smitt en 1895; Calderwood en 1905; Zschokke en 1905; Hoek en 1900—1910, qui note que des parrs mâles peuvent être mûrs dans le premier automne de leur existence; Arvidsson en 1910; Carr en 1912; Huitfeldt-Kaas en 1914; Knut Dahl 1911—1915—1929—1944 qui précise à son tour que cette précocité sexuelle ne se rencontre en Norvège *que chez les mâles* âgés de 2 ou 3 ans;

Otterstrøm — 1914 — identifiant des parrs mâles sexuellement mûrs de 1 ou 2 ans, parmi un lot d'alevins conservés en étang au Danemark.

Nordquist et Alm en 1927; Pablo Larios y Sanchez de Pina — Marques de Marzales — 1927 — signalant un cas de parr mâle mûr dans la rivière. Pas en Espagne;

Bouisset et Larrieu — 1929 — qui précisent que pour le bassin de l'Adour en France, les mâles mûrs sont normalement âgés de 2 ans. Isatchenko en 1931; Berg en 1935; Smirnov en 1935; Koutchina en 1935; Kendall en 1935 — signalant à son tour l'existence de la précocité des parrs mâles chez les saumons américains; Chimits en 1936 — pour le bassin de l'Adour, qui note la maturation sexuelle exceptionnelle de parrs de 1 an;

Dorier en 1936 — confirmant pour un parr élevé en captivité une maturation sexuelle à 9 mois; Huntsman en 1936 — pour les saumons canadiens; Orton, Jones, et King en 1938, de l'examen des études antérieures et des leurs, concluent que toutes les observations sont d'accord pour reconnaître *que tous les parrs femelles sont immatures* et que le cas des parrs mâles matures est fréquent. Pour la rivière Dee, qu'ils ont étudiée, ils arrivent à la conclusion que 40 % de l'ensemble des parrs mâles de 2 ou 3 ans arrivent à maturité sexuelle. Ce phénomène doit donc être considéré comme normal;

Tchernavin en 1939, sans apporter de faits nouveaux, publie une mise au point très utile sur cette question. Il tire de cette revue d'ensemble quelques conclusions intéressantes et notamment que les parrs mâles peuvent se reproduire deux fois avant de descendre à la mer et qu'ils sont habituellement âgés de 1 à 4 ans. Il signale quelques très rares cas de parrs femelles mûres. Nous allons revenir plus loin sur cette question; Jones et Orton en 1940 — de l'étude des parrs et smolts de plusieurs rivières anglaises retiennent:

que les sexes mâles et femelles sont en nombres équivalents,

que tous les parrs femelles sont des immatures,

et que parmi les parrs mâles 75 % sont sexuellement matures, alors que cette proportion tombe à 60 % pour les smolts gardant trace de maturité sexuelle, ce qui peut provenir d'une mortalité après le frai.

Nos propres observations de ces dernières années, sur le Gave d'Oloron, nous conduisent à retenir que sur cette rivière:

le pourcentage des sexes parmi les smolts est de 35 à 40 % de mâles contre 60 à 65 % de femelles;

le pourcentage des sexes chez les parrs est du même ordre s'ils sont capturés par vidange d'un canal par exemple. A la ligne ou au filet les prises de parrs femelles sont peu fréquentes. Elles sont tout à fait exceptionnelles sur les frayères de saumon, en hiver, comme le signalait déjà Shaw en 1840.

Les smolts descendent à la mer à 1 an ou 2 ans, en proportions égales. Les smolts de 3 ans sont très rares.

Parmi les smolts de 1 an, ceux qui ont frayé l'hiver précédent (testicules au stade VII) sont une minorité.

Parmi les smolts de 2 ans plus de la moitié ont frayé l'hiver précédent.

Les oeufs de saumons adultes, fécondés par de la laitance de parr, évoluent normalement.

Nos propres observations confirment donc les observations de nos devanciers et nous conduisent à conclure, avec Orton et Jones, que la maturation sexuelle des parrs mâles n'est pas une exception et doit être considérée comme un phénomène naturel dans le cycle génétique des saumons.

III. Elaboration d'ovules matures par un parr de Saumon.

1. Observations anatomiques.

Dans la nuit du 26 au 27 Décembre 1947, procédant à des reprises de parrs pour expériences sur les frayères de saumons du Gave d'Oloron, quel ne fut pas notre étonnement de trouver, au milieu d'un lot de parrs mâles, tous matures, un parr qui ne donnait pas de laitance et dont à la pression on sentait les oeufs fluctuer dans la cavité abdominale.

Ne pouvant obtenir ces oeufs par simple pression, une incision fut pratiquée et nous avons pu récolter 102 oeufs entièrement libres que nous avons fécondés avec de la laitance de parr mâle, et mis en incubation à l'établissement de pisciculture de la Société de Pêche d'Oloron. Une

fois fécondés et gonflés par l'eau ces oeufs mesuraient 5 mm. de diamètre.

Furent mis en incubation également comme lots témoins à la même pisciculture:

oeufs de saumon x sperme de saumon,
oeufs de saumon x sperme de parr,
oeufs de truite commune x sperme de parr.

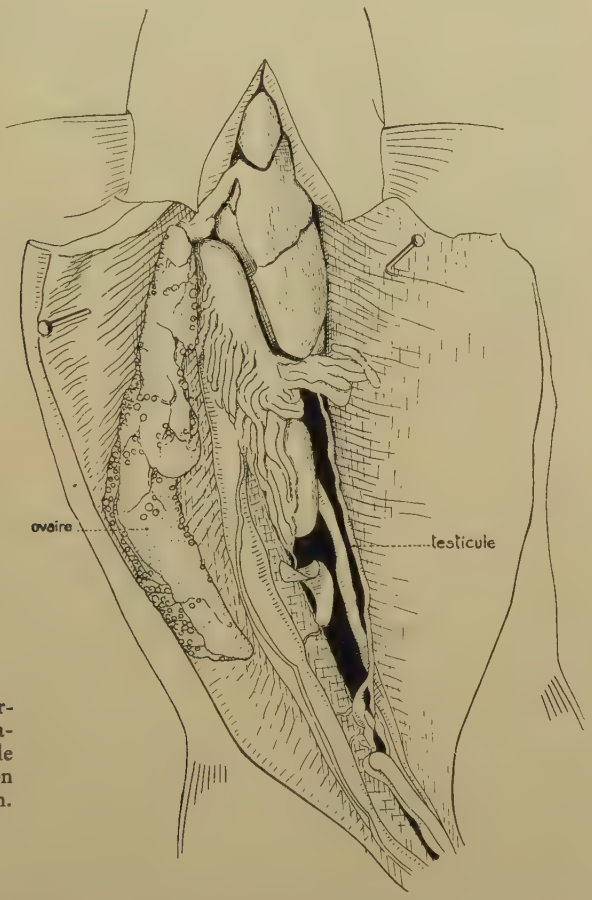

Fig. 1. Parr de saumon hermaphrodite parvenu à maturité sexuelle, capturé le 26 Décembre 1947 à Oloron (B.P.) sur le Gave d'Oloron.

Vu le caractère extraordinaire et unique du phénomène, une précaution s'imposait, s'assurer qu'il s'agissait bien d'un parr de saumon et non d'une truitelle.

Le tableau donné en annexe, donnant côte à côte les photographies du parr en question (138 mm. — 28 gr. après la ponte) et d'une truitelle commune (128 mm. — 20 gr.) avec les caractères distinctifs des parrs et des truites, d'après O t t e r s t r ø m 1935, montre que nous nous trouvons bien devant un parr de saumon, animal que nous avons mis au

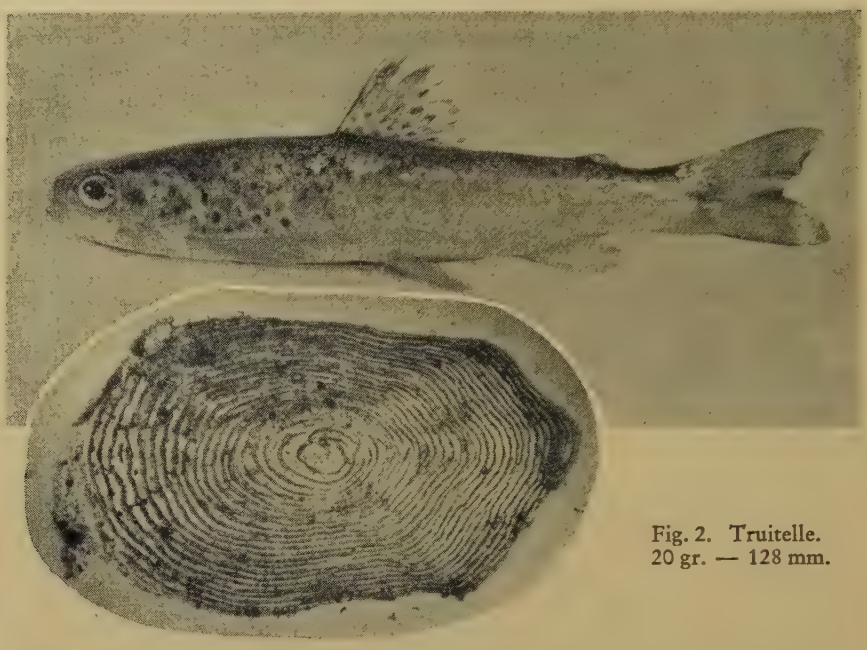

Fig. 2. Truitelle.
20 gr. — 128 mm.

1. Tête plutôt élevée et massive.
2. Museau (vu du dessus) plutôt large.
3. Maxillaire supérieur — dépassant la verticale tangente à l'arrière de la pupille.
4. Nageoire pectorale (rabattue sur le flanc) — pointe n'atteignant *habituellement* pas la verticale abaissée de la naissance de la dorsale (ici l'atteint).
5. Echancrure de la nageoire caudale — nettement prononcée.
6. Taches de l'opercule — 4 et 5 taches noires petites (3 à 5 suivant Otterstrøm).
7. Taches bleu grisâtre des flancs — 4 à 5 taches grises faiblement marquées (moins de 8 suivant Otterstrøm).
8. Ponctuations rouge vif des flancs (en alternance avec les taches bleu grisâtre) une vingtaine, cernées d'un liseré brillant.
9. Adipeuse — partiellement orangée.

formol et déposé au Laboratoire de Physiologie générale du Muséum d'Histoire Naturelle à Paris comme pièce à conviction.

L'examen ultérieur de l'animal révéla une autre particularité:

côté droit, ce parr présentait un ovaire encore très volumineux, avec sa disposition foliacé typique, les oeufs de la ponte future étant déjà parfaitement visibles;

côté gauche, il possédait un testicule filiforme qui à première vue semblait tout à fait au repos et que nous classâmes dans le stade I de Jones (Fig. 1). Mais l'étude histologique [1]) montrait que si ce testi-

[1]) Nous remercions vivement Mademoiselle Odette Tuzet, Professeur à la Faculté des Sciences de Montpellier qui a bien voulu examiner les préparations histologiques et nous donner son avis très précieux de spécialiste.

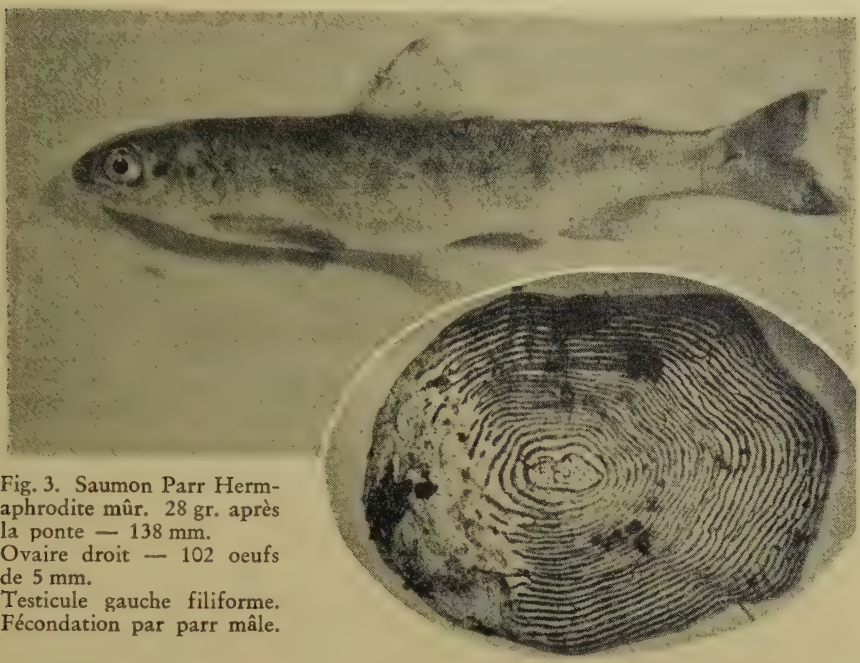

Fig. 3. Saumon Parr Hermaphrodite mûr. 28 gr. après la ponte — 138 mm.
Ovaire droit — 102 oeufs de 5 mm.
Testicule gauche filiforme.
Fécondation par parr mâle.

1. Tête plutôt effilée.
2. Museau plutôt effilé.
3. Maxillaire supérieur n'atteignant pas la verticale tangente à l'arrière de la pupille.
4. Nageoire pectorale (rabattue sur le flanc) — pointe *atteignant* ou même dépassant la verticale abaissée de la naissance de la dorsale.
5. Echancrure de la nageoire caudale — nettement prononcée.
6. Taches sur l'opercule — 3 grandes taches noires (1 à 3 suivant Otterstrøm).
7. Taches bleu grisâtre des flancs — 9 taches bien marquées (8 à 10 suivant Otterstrøm).
8. Ponctuations rouge vif des flancs (en alternance avec les taches bleu grisâtre) 12 et 14, sans liseré.
9. Adipeuse — gris verdâtre clair.

En résumé sur 9 caractères qu'il a été possible de retenir suivant les critères formulés par Otterstrøm [1]) (1935) 2 manquent de précisions (No. 4 et 5) les différences n'étant pas sensibles. Les 7 autres paraissent bien significatifs et conduisent à la conclusion que le poisson pêché à Oloron le 26 Décembre 1947 est un jeune saumon, ou tocan, ou parr. La lecture de son écaille indique comme âge: 2 ans.

[1]) Otterstrøm 1935 — Saumon et truite — Directives pour leur différenciation — Bull. Français de Piscicult. No. 89 — Novembre 1935.

cule était manifestement atrophié, il n'y avait pas dégénérescence. Sans doute de part et d'autre du canal déférent n'existe-t-il qu'une seule rangée d'ampoules mais on y trouve des spermatides à divers stades de leur développement. Enfin quelques spermatozoïdes qui semblent proches de leur maturité, sinon complètement mûrs, sont présents. La gonade mâle atrophiée, avait donc pu cependant élaborer — en nombre réduit — quelques gamètes mâles et, sans notre capture, la possibilité n'aurait

pas été exclue que ce parr eut fécondé ses propres oeufs. Un rapprochement s'impose entre cet exemplaire exceptionnel de *Salmo salar* et celui de *Salmo fario* étudié par Charles Stewart, pour lequel il y avait aussi hermaphrodisme et maturation synchrone des produits génitaux mâles et femelles.

2. Observations ultérieures sur le développement des oeufs.

La première phase de l'incubation eut lieu du 27 Décembre 1947 au 16 Février 1948 à la Pisciculture de la Société de Pêche d'Oloron située sur le Gave d'Ossau (températures extrêmes 5 et 9° centigrades).

Le 16 Février 1948, après embryonnement, les oeufs furent portés à la pisciculture domaniale de Lees-Athas alimentée par eau de source à 7°.

Lot témoin: saumon mâle x saumon femelle.

— Fécondation du 31 Décembre 1947.
— Embryonnement commençant le 8 Février 1948 (40 jours).
— Eclosion commençant à Lees-Athas le 27 Février 1948 (59 jours), partie restée à Oloron commençant le 26 Février 1948.
— Mortalité de la fécondation à la résorption de la vésicule: 5 % environ.

Lot: parr hermaphrodite x parr mâle.

— Fécondation 102 oeufs du 27 Décembre 1947.
— Embryonnement commençant le 5 Février 1948 (41 jours), 6 oeufs furent embryonnés.
Les autres oeufs, ouverts, ne contenaient pas trâce d'embryon visible. Déficit à la fécondation pouvant provenir d'une maturation légèrement insuffisante des ovules que nous n'avons pu obtenir que par incision.
— Eclosion les 24—25 Février (60 jours) de 5 alevins.

Alevins presque aussi longs que ceux issus de saumons adultes, mais beaucoup plus minces et d'une couleur beaucoup plus claire et moins vive. Vésicule également plus petite, de forme arrondie ressemblant à celle de la truite. Résorption plus rapide que chez les alevins issus de saumons adultes du lot témoin.

Un alevin disparut. Deux moururent par accident, la vésicule (très petite) prise dans les trous de la tôle perforée des incubateurs. Le 4 Mai les 2 uniques survivants furent placés dans un bac, sur fond de gravier, avec quelques touffes de cresson, une truitelle réussit malheureusement à pénétrer dans le bac par le robinet d'alimentation, ... et fit disparaître ces deux derniers sujets en observation.

Lot: saumon femelle x parr mâle.

— Fécondation du 27 Décembre 1947.
— Embryonnement commençant le 3 Février 1948 (39 jours).
— Eclosion commençant le 27 Février 1948 (63 jours).
— Mortalité de la fécondation à la résorption de la vésicule: 5 % environ. Alevins de même taille que ceux de saumons adultes mais de coloration plus vive.

Lot: truite femelle x parr mâle.
— Fécondation du 27 Décembre 1947.
— Embryonnement commençant le 1 Février (37 jours).
— Eclosion commençant le 28 Février (64 jours) et s'étendant sur plusieurs jours. Alevins très petits, porteurs d'une grosse vésicule semblant recouverte d'un voile.
— Mortalité de la fécondation à l'éclosion: 20 % environ.
— Mortalité de la fécondation à la résorption de la vésicule: 100 %.

On peut remarquer que la durée *totale* de l'incubation est plus courte dans le cas de la fécondation *normale* saumon x saumon que dans les trois autres cas de croisement. Aucune remarque n'est à tirer du temps nécessaire à l'embryonnement. Il est vrai que cette phase de l'évolution est beaucoup moins facile à préciser que l'éclosion, en particulier dans un établissement très sombre. Les chiffres fournis sont donc moins exacts.

Etant ainsi convaincu qu'il s'agissait bien là d'un parr hermaphrodite mûr dont l'ovaire était toutefois beaucoup plus développé que le testicule, nous avons effectué des recherches bibliographiques plus approfondies et nous avons constaté que, si le fait est beaucoup plus rare que pour le mâle, il a déjà été signalé quelques parrs femelles matures.

Tchernavin en 1938 cite les noms des auteurs suivants: Shaw, Frank Gosden, Day, Schäferna, Smirnov et Regan.

Shaw en 1840 note en effet qu'il a été signalé que des parrs femelles de grande taille (22 cm. à 25 cm. de long) ont été trouvées avec des oeufs très développés et lui même, gardant des smolts femelles en eau douce jusqu'à la fin du troisième hiver, a observé des individus dans cet état. Il est cependant impossible, d'après ces indications très sommaires, de savoir s'il s'agit d'un développement important des ovaires ou d'une maturité complète du jeune saumon femelle.

Frank Gosden (Land and Water) cité par Day (1885) affirme que dans le Exe, le smolt peut émettre ses oeufs au moment de sa capture. Les précisions manquent toutefois, mais Day qui a élevé à l'établissement de pisciculture d'Howietoun des parrs et des smolts a observé la maturation des ovaires chez plusieurs individus à partir de l'âge de 32 mois.

Il faut cependant souligner qu'il s'agit là d'observations faites sur des élevages en captivité et non sur des prises dans la nature.

Nous n'avons pu consulter le travail de Smirnov.

Quant à Regan, il note qu'une femelle parr de saumon avec les ovaires complètement développés a été capturée dans la Teme en Septembre 1937. Ce poisson qui mesurait 9 pouces de long et était âgé de 2 ans et demi, présentait très nettement les caractères distinctifs du saumon par rapport à la truite. Cette dernière note est particulièrement instructive car l'autorité de Regan et le soin qu'il prend à souligner qu'il ne peut s'agir d'une jeune truite, montre bien qu'il ne peut guère être mis en doute qu'on se trouve en présence d'un parr femelle sexuellement mûr. Toutefois on ne peut que regretter de ne pas posséder une description

plus complète de cet exemplaire et que des tentatives de fécondation n'aient pas été effectuées.

Quoiqu'il en soit notre observation représente la première signalée en France d'un cycle pédogénétique femelle du saumon, et il semble bien que ce soit la première fois que des oeufs de parrs femelles aient été fécondés artificiellement avec succès. D'autre part l'échantillon que nous avons capturé semble être le plus jeune parr porteur d'oeufs mûrs qui ait été jusqu'ici signalé. Nous avons cru bon de rapporter ces observations car plus nombreux apparaissent les exemples de ce genre, et moins exceptionnelle se révèle la possibilité d'un cycle pédogénétique complet et holobiotique d'une espèce et d'une race de saumon cependant typiquement migratrice. Sans doute nous connaissons depuis longtemps des saumons sédentaires et nous savons que certains au moins dérivent incontestablement de saumons migrateurs, mais n'est-il pas plus hautement suggestif encore, pour nos réflexions sur la plasticité du caractère migrateur et sur son évolution, de concevoir pour un couple déterminé, la possibilité d'un premier cycle génital entièrement accompli dans les eaux douces de la naissance, lui-même suivi d'un second cycle amphibiotique. Ces couples encore exceptionnels chez le *Salmo salar* apparaissent toutefois comme des intermédiaires les plus hautement significatifs entre la race de saumon holobiotique et la race amphibiotique.

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Essay Review.

By

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"A Symposium on Fish Populations held at the Royal Ontario Museum of Zoology, Toronto, Canada, January 10th and 11th, 1947." Bull. Bingham Oceanogr. Collect., Vol. **11**, Art. 4, New Haven, Conn., 1948.

A. G. Huntsman. "Fishing and assessing populations."

T. H. Langlois. "North American attempts at fish management."

J. R. Dymond. "European studies of the populations of marine fishes."

M. D. Burkenroad. "Fluctuations in abundance of Pacific halibut."

D. Merriman and **H. E. Warfel.** "Studies on the marine resources of southern New England. VII. Analysis of a fish population."

A. W. H. Needler. "Estimating fishing intensities."

W. E. Ricker and **R. E. Foerster.** "Computation of fish production."

R. E. Foerster. "Prospects for managing our fisheries."

W. C. Herrington. "Limiting factors for fish populations. Some theories and an example."

This symposium on fish populations is welcome because of the strong challenges it contains to several of the main elements of the generally accepted theory of fisheries and for the indictment it makes of certain injudicious claims. The symposium consists of nine papers of which five are reviews and expressions of opinion, and four submissions of results whilst also submitting views. The papers contain a great deal of provocative material, out of which only the main items can be dealt with here. Each paper is followed by the record of the discussions which took place after its reading, which are interesting and revelationary.

Huntsman submits the questions, Does it ever pay to allow fish to remain uncaptured in order to allow them to grow more? and, Is there ever really any deficiency of reproductive potential? He examines certain North Sea and east Canadian fisheries and, it is not unfair to say, concludes that the answer is generally, No to both questions. His major argument is a piece of calculation in connexion with North Sea fisheries; but it depends on the validity of using the average annual catch 1910—14 as a measuring stick for the periods 1914—18 and 1919—24 — a procedure which is well designed to start a contentious discussion, on account of its crudity. Huntsman

also proposes description of states of fishing in terms of definite properties, and sets up 11 cases, giving his explanations.

The papers by Langlois, Dymond, Needler, and Foerster are also reviews and the submission of opinions.

Burkenroad has apparently come to the conclusion, from his starfish work, that the importance of natural fluctuations has hitherto been neglected in fisheries work and that in fact it is such as sufficiently to explain the bulk of the phenomena of fluctuation in catch taken by fishing operations. Having reached this conclusion he seeks to show that it may validly be applied to this famous instance of biological analysis and management, the north Pacific halibut, and in discussion (see pp. 126—7) he indicates his willingness to believe it to explain any other fishery phenomena. His argument begins with the evidence (from the programme which otherwise he seeks to discredit) that the fishery of 1927 caught 30 million pounds of fish and that this was 10 % of the total population; he then accepts other evidence that the population in 1915 was three times the population of 1927 and argues that it must therefore have consisted of 900 million pounds of fish; he then presents the catch statistics and says that the total catch over the years 1915—27 was only a fraction of the total presumed mortality in the period.

The paper by Merriman and Warfel reports the results of sampling demersal stocks off the New England coast of the United States in a regular monthly programme. Thirty one, one-hour, hauls were taken with a drag net of 80-foot mouth in water of depth 10 to 25 fathoms. These hauls were taken monthly with interruptions, due to weather and so forth, on five occasions: the survey covered three years. In each case the entire haul was taken to the laboratories for detailed biological examination. The data thus obtained were analysed in respect of species composition, as individuals and weight in relation to season. This work presents a more than usually detailed picture of the composition of the catch taken in certain commercial operations, and we await further results. At present the sampling seems uneven, with hauls varying from $^1/_2$ hr. to over 2 hrs.

Ricker and Foerster have presented an account of the computation of what they call fish production in Cultus Lake, British Columbia. It should be stated at once that the computation is of production of young sockeye salmon to participate in the migration to sea and that although the authors have incorporated detailed analysis of weight considerations in their work, the essential point is the output of seaward moving migrants to join to the sea population of sockeye. The significance which the average weight at time of migration might have on the survival or subsequent size for catching or on fecundity (if surviving to reach the spawning ground) is not considered.

The computations are not submitted as representing final results and it must be noted that the whole work is presented with a fine diffidence; this is noteworthy in view of the significance of the contribution. The statement on pp. 188—189 to the effect that "for any given mortality rate the ratio of production to yearling stock is almost constant, in spite of rather large changes in rate of growth" is an overstatement on the figures presented in Table V for which the correlation between the figures given in Columns 4 and 6 is 0·6 with a probability of about 0·1. The section on production and food consumed prompts a query as to the relation of the sockeye stocks to the remainder of the lake biota and as to the relative efficiency of sockeye as against other mega-biota as converters of energy. The section on sockeye and predators seems to establish clearly that a reduction in the biota

preying on sockeye results in significant increase in the survival of the sockeye and that this is a consequence of reduced predation rather than of increased availability of food per sockeye.

Herrington's data do not include estimates vital to his argument, namely of the rate of natural mortality, the real fishing effort, migration, food supply, and reproduction. Instead, he has only the figures of total landings of haddock from Georges Bank, and unsatisfactory estimates of catch per unit of effort and of the catch of small haddock, "scrod". He is nevertheless convinced that the haddock stock requires attention, and the fishery some regulation. In the present paper he attempts, not entirely successfully, to convey to the reader the thought-processes by which he has reached his position.

The phenomena that he finds are:—

(i) that at lower levels of density of adults, the more the adults the more their progeny in a subsequent fishery;

(ii) that at higher levels of density of adults, the more the adults the fewer the progeny in the fishery;

(iii) a shift in the critical level, at which the relation becomes inverse, in 1940 or thereabouts. This is a very big shift, nearly by one half, from 23 units to 13, as read from his graphs.

Establishment of the third phenomenon would excuse anyone from believing in the reality of the first two, based as they were on derived indices, of which the sampling error is incalculable. Herrington's paper could never, therefore, provide a good basis for interfering with other people's way of making a living, that is, by fishing.

On the basis that the phenomena are real, Herrington has erected a theoretical model to explain them. It is unfortunate that, in exposition, he reverses the process, giving his theory first, as it were *ex cathedra,* in which guise parts of it are not easy to believe. On this theory, egg production is related to numbers of adults in strict proportion, but he allows that predation, on eggs and larvae, ceases to rise proportionally when egg production is high, because the number of such predators must, in the end, have some limit. Thus Herrington obtains the chief component to the explanation of phenomenon (i), the positive association of numbers of adults and recruits, and some allowance towards explaining the second phenomenon.

Turning to consider the limit set by food supply, his theory is that it is not effective at low levels of stock density, and that food shortage becomes effective, not merely in reducing growth but also in increasing mortality, at higher levels of stock density. Thus phenomenon (ii) is explained — a negative association of number of adults with number of resulting progeny of commercial size.

Phenomenon (iii), the greater competitive effect of adults from 1940 onwards, requires the bringing in of some new factor, and scarcity of food is the one chosen. Herrington shows that the fishing for the adults was rather more spread over the nursery areas in 1943 and 1944 than formerly, indicating perhaps a shortage of food in the normal adult areas. (I am indebted to Michael Graham for the foregoing paragraphs reviewing Herrington's paper, and for help in editing the remainder of this essay.)

Because of the vigour of the attack which some of these papers make on certain loosely held views, or unwisely advanced claims on behalf of fisheries theory, it will be well to examine them in relation to the current status of fisheries science.

The following statement is a summary account of what, in my view, has emerged in the significant fishery writings of the past fifty to seventy-five years. Hjort (1938), Russell (1942), and Graham (1943) have given general expositions and I (Kesteven 1946 a and b, 1947 a, and 1948) have lately presented statements together with some development of these ideas.

(1) In the modern view a stock of fish[1]) is regarded as a living, self-maintaining entity capable of sustaining the exploitative activities of man for an indefinite period provided those activities hold a proper relation with the stock and the several other factors by which it is influenced.

(2) This view maintains further that an understanding of the stock of fish and of all the factors by which it may be influenced is required for the benefit of the fishing industry, whether it be to assist the industry in developing its operations to the fullest degree compatible with the term "proper relationship", or to assist it in maintaining that proper relation, by forecasting changes in the availability[2]) of stock and proposing compatible changes, upwards or downwards, in the intensity of fishing operations.

(3) The modern theory of fishing requires that distinct and virtually autonomous units of stock should be identified (see, for instance, R. et P.-V. 1929, and Rounsefell and Dahlgren 1935) and recognizes that the stock of fish is composed of age and sex-groups, and that other groups, such as fast growing as against slow growing, may also be identified (Lea, 1929).

(4) It maintains that a detailed analysis of the behaviour of the individuals and of the stock as a whole, by way of migration, feeding, and reproductive habits and so forth is essential to an understanding of the structure and dynamics of the population. (See, for instance, the bibliography on this subject by Russell and Bull (1932) and the many works on fish migration.)

(5) It submits that the stock, *qua* population, is possessed of certain properties which must be measured; these properties include the potentials for growth and reproduction and are opposed by a force of mortality, corresponding to which there may perhaps be considered a third property of "survival" (see especially, Kesteven 1946 and 1947 a).

(6) It maintains that the effective expression of these three properties in any period is the result of the forces within the population interacting with the forces outside of it and that this is extremely variable from year to year; that this variability differs among populations (Volterra 1928); that in a natural state a population may be assumed to achieve a condition of dynamic balance oscillating variably about some natural level of abundance; that conceivably, as part of the operation of evolutionary processes, the operation of repressive environmental forces might impress a downward swing on the achieved level of dynamic balance, or a similar effect might be brought about by some significant genetic change in the population, and that this might lead to elimination of the population.

(7) The theory distinguishes between adult and immature fish, and between commercial stock and brood, the latter being the reservoir from which recruits are drawn into the former (e.g., Thompson 1930). Recruitment

[1]) This view includes, logically, the case where human fishing is a negligible factor among all those by which the fishery is influenced and in which the "proper relationship" may be a very loose one indeed.

[2]) See below, on availability.

may of course be merely a function of fluctuation of time, as of one year-class into another, or of physiological, and variable, processes, as of from one size-group into another and this latter is related to technological recruitment into a size-group which can be captured by gear employed: a legal question is involved here also.

(8) The reproductive potential is a function of the sexual composition of the population, its total fecundity, the favourability of the environment for spawning, hatching of eggs, and survival of the eggs, larvae, and so forth. The growth potential is a function of size, age (and perhaps sex) composition of the population, availability of food (including competition forces tending to reduce food availability) and favourability of the environment to effective use of ingested food. Survival is dependent upon prevalence of predators and other inimical factors.

(9) In respect of fishing operations the theory maintains that the degree to which fishing mortality supplements natural mortality (recognizing the competition between these two causes of mortality) must be considered in conjunction with the population potentials of growth and reproduction; it asserts that this relationship is variable, from year to year in the one fishery, and from fishery to fishery. The intensity of the effect of fishing operations upon the stock will depend upon the total mortality-rate thus imposed on the population, and upon the section of the population removed; the effect will be not only the arithmetic subtraction of individuals but also the effect on the potentials of growth and reproduction, the former being allowed greater scope, the latter being suppressed, by the removals. The theory maintains that these effects should be measured and appraised, and that it is possible to calculate for each stock a level of catch optimum in respect of the properties of the population.

(10) In respect of technique the science makes recourse to economic and technological data as well as certain biological and hydrological methods; one of its distinguishing features is its employment of commercial statistics as evidence of the population, in relation to abundance and composition, but the science insists upon proper calibration of these data. This view will recognize the possibility that whilst the removals by fishing operations might be apparently negligible relative to the total natural mortality, they might, if added to the downward bending phase of a natural fluctuation, serve to prolong that phase into dangerous levels at which the fishing removals could become extremely significant and serve to hold the fish stocks at the lower levels. It also insists on measurement, as far as possible, of all the factors which determine the intensity of fishing[3]); these include not only the absolute figures of numbers of units of various types of gear, but estimates of their mechanical efficiency, allowance for economic factors influencing the frequency and efficiency of their use, and so forth.

Certain topics require specific consideration and this is given in the following sections.

Relation of Reproduction Potential and Recruitment at Various Stages.

On this question the symposium reflects the prevailing uncertainty. Dymond contributes to a view held by other distinguished workers; "Search for an explanation of the causes of the wide differences in the size

[3]) By intensity of fishing we mean the number of units of standard fishing effort per unit time.

of different year-classes has brought out the fact that there is no necessary connexion between the number of eggs produced in a particular spawning season and the number of fry which survive". Herrington, postulating a lineal relation between egg production and the adult population, commits the error which justified the unbelief which Dymond voiced: that is, he proposes a direct correlation.

For our part we maintain that the argument, from spawning population to recruitment into any age or other group, must be made by stages; the first stage should allow not only for sex ratio but also for the variation in fecundity which accompanies differences in size (Raitt 1933). The next stage in the argument must be to allow for reduction of the initial potential to an effective potential, effective to some chosen point such as hatching, or the successive stages of larval, post-larval, and young fish development. In the course of this development the numerous factors which operate to cause reduction must be observed and correlations estimated between the intensity of these several factors and the resultant reduction. Naturally, the significant factors must first be identified and the task of measuring these and the population of eggs, then of larvae, post-larvae, and so forth is immensely involved and arduous. Yet this is the road by which an understanding of the relation between spawners and the subsequent recruitment is to be reached.

Among the factors which must be considered in this complex, the depredations of fishermen on the spawning stock must be considered impartially with all others. Its rôle has never yet been measured in the way described above.

Herrington believes that recruitment is largely determined, at high levels of population density, by the operation of intra-specific competition between adults and juveniles of 8—10 months. In so far as this is a question of mortality it is commented on below but, for my part, I find little in Herrington's paper to lead me to abandon the established idea that brood strength is determined principally in the egg, larval, and post-larval stages. In point of fact, such evidence as exists, in Herrington's Figures 11 and 12, of diminished recruitment at higher population levels points to the fact that this phenomenon might be established at the very beginning of the life of the fish.

Mortality.

Material on mortality is offered by Ricker and Foerster, and by Herrington. The former have three suggestions to make:—

(1) that "the years of large initial sockeye populations, and hence of slow growth, should be years of poor survival-rate, because of the prolongation of the period of unusual vulnerability which followed the emergence of the fry from the redds."

(2) "If the observed short rations....were even less for the much larger population,....might not a point be reached where some fry would actually die from loss of weight?"[4])

(3) "The net result of this observation is to make it appear perhaps a little more likely that an appreciable amount of non-predatory mortality occurs, without giving any clue as to its cause or its quantitative importance."
(N.B. These three suggestions are quite independent).

[4]) The food supply of fry generally is not the food of adults and therefore inter-age-group competition is not implied here.

These are special suggestions supplementing their analysis of known predation, and offered as most tentative possibilities.

Herrington considers the following types of mortality:— (1) inter-specific predation, (2) intra-specific competition-caused mortality of which he identifies two types, (a) intra-class competition, (b) inter-class competition; the former is considered only in relation to eggs, larvae, and young fish and its rate is held to diminish with the increase in the population of eggs, larvae, and young fish. Of the first-named type of mortality I believe that the relationship of prey and predator in most natural populations must be such that an upward trend in the prey population will be followed by similar trends in the predator and that the oscillations of the population of the one will be within the reach of the oscillations of the other.

Throughout his paper Herrington speaks of competition-caused mortality in clear distinction to predation and the impression conveyed by the paper is that he considers competition-caused mortality as a quite separate item, presumably a matter of death by starvation. On this it may be observed that it would be necessary to show a more distinct condition of emaciation before one could accept that such fish died from starvation. Emaciation is not indicated by achievement of less-than-average size. On the other hand, the suggestion by Ricker and Foerster is attractive, namely, that a large population, causing a low growth-rate, might hold individuals within a vulnerable stage for a longer period than at other times when greater food supply per individual permitted greater growth-rate. I think, too, that increased density of prey would increase the efficiency of operation of the predator. Of non-predative mortality, the evidence on this is most meagre (apart from major calamities) although starvation might be a factor in certain especially vulnerable groups, and there may exist other forms of non-predative mortality.

Growth Potential.

The paper by Ricker and Foerster is of considerable interest and importance because of its direct approach to the question of growth potential and the relationship of this to population density and availability of food. In this connexion we may here take into consideration a paper by Hickling (1946). Against some resistance, the idea has gradually developed that (doubtless within limits) average growth of a year-brood, at any interval of time or stage of its life, is a function of the availability of food per individual of the brood. Whilst this implies an inverse relationship between growth-rate and population density (Raitt, 1936) the relationship might not be presumed simple, even *a priori*, for if the fish population level may fluctuate, so may the level of food supply and far from such fluctuations being expected to occur in unison they are known to be otherwise. Consequently the problem of growth must be dealt with as a multiple correlation of food supply, population level, and growth-rate. Hickling (l. c.) reports that haddock on Porcupine Bank, September 1944, revealed a very considerable increase in population level and, contrary to expectation, did not show any slowing of growth-rate; it may be observed that this expectation would have been reasonable if the accompanying availability of food were measured, but under the circumstances it must be presumed that in this case there was unprecedented increase in food supply — possibly as a result of the operation of the same factors as those which caused the increase in the fish stock.

Ricker and Foerster show the seasonal variation in growth-rate

which has come to be expected in most growth curves and to be associated in our minds with the problem of the cause of annuli in scales and other hard structures. Their Figure 1 shows variation in the curve of three different years: it would be interesting if further development of this programme could show within what limits of availability of food per individual the average growth-rate were actually sensitive; whether, for instance, there were any practical maximum or any minimum below which, in the absence of predators, slower growth would result in the supervention of death. It is interesting that Ricker and Foerster consider that the increased production of sockeye salmon which they observed in Cultus Lake after the removal of predators was a result of reduced predation rather than reduced competition for food (p. 203), a conclusion which they say is contrary to that reached by Rounsefell (1946) for a similar population. However, they consider the seasonal growth pattern to be somewhat similar from year to year.

Natural Fluctuations.

The existence of considerable fluctuations in the level of natural populations can hardly be regarded as a matter for disputation. In fisheries there has been a great deal of work on this question (Hjort 1914 R. et P.-V. 1930) and reference may be made to standard work such as Elton (1927). The remarks of Burkenroad and of Huntsman might be taken to imply that they felt that the existence of such fluctuations had been overlooked, or at least that its importance had been underestimated; it is possible that the halibut work may reveal that insufficient importance had been attached to the significance of these fluctuations, but this possibility in no way argues that fishing has no effect on fish populations or that the general theory of fishing is at fault.

Fishing Operations.

A distinction must be made between the statistical series which sets forth the total catch[5]) and those which relate to the fishing effort. The statistics of total catch may of course be tabulated to show the amounts taken in different areas and times. However, these figures are, in themselves, not very meaningful; they may convey much when related to the fish population on the one hand and to the economic and technological aspects of the industry on the other hand; they certainly have their magnitude as a consequence of the availability of the fish for the fishing operations and because of the various economic and technological factors which determine intensity of fishing but they may not be used, alone, as argument to these things (Huntsman l. c. and Ottestad 1942).

Fishing intensity is represented by the amount of fishing, measured in terms of a standard unit, which takes place per unit time. As has been demonstrated in the voluminous fishery publications, catch can be related to effort in an index, catch per unit effort, and in many cases care has been taken to allow effectively for variation in effort, that is to say, variation in intensity of fishing (see Sette 1943). This is necessary for two reasons: (1) unless this is done the units of effort are not comparable; (2) unless this is done, also the effect of fishing on the population of fish cannot be allowed for. If this adjustment is properly made it is possible that the resultant

[5]) of a species under examination.

statistics, catch per unit effort, may form a reliable index of changes in population level — without a lot of further data they do not indicate absolute level, but obviously if the absolute level of one year can be measured accurately, and the relative position of the others known accurately, their absolute values may be calculated. But it is to be stressed that not only must the technological and other changes in the Industry be accurately measured but also the fundamental changes in the population itself must be observed. Now in these papers we have (1) Herrington stating "the expansion of operations in 1930 and 1931....resulted in improvement of fishing methods greater than we were able to measure and bring into adjustment" (l. c., p. 254) and (2) Burkenroad stating "The degree of probability that the ratio of catch-per-unit effort to population on the western grounds changed... between 1915 and 1927 cannot be assessed" (l. c., p. 98). Both of these statements strike at the root of the calculations presented by these authors. In the case of Burkenroad it seems to us very possible that the ratio referred to in his quotation did change; and that the calculation of population size in 1927 was on false premises for this and other reasons, and, finally, that the calculation of absolute population levels in 1915 and other years by way of relative levels from the absolute level calculated for 1927 is thus made unacceptable.

Management projects are not rightly scorned as merely experiments; undoubtedly every human action is in the nature of an experiment for some observer.

Method and Terminology.

I take exception to the practice, employed in several of these papers, of assuming rates, notably of natural mortality. It is clear that this a factor of very considerable importance, and in fact Burkenroad's main thesis is that it is the principal factor. It is certainly likely to prove of such importance that much of fishery research is in effect directed toward the measurement of this factor; therefore the assumption of mortality-rates is unjustifiable and conclusions based on such assumptions are untenable. Furthermore, there seems to be no reason why mortality should be assumed constant, either as a rate or as an absolute amount; it seems much more reasonable to recognize that these populations are complex systems, comprising numerous interacting factors, and that the strength of the operation of any relationship will be an extremely variable thing and not to be assumed. As an example of the type of logical impasse into which these assumptions of natural mortality lead, the following is from Herrington (l. c., p. 257):— "If values below 325 million are used for the original stock, a natural mortality of less than 10 per cent. must be assumed to avoid negative values for the stock at the beginning of 1932. On the other hand, if values above 400 million are used, a natural mortality of more than 15 per cent. must be assumed to avoid values for the 1932 stock which are much in excess of that indicated by the catch analysis data. Therefore, it seems very probable that the actual population of marketable fish at the beginning of 1927 was between 325 and 400 million fish, and that the average mortality during the following years averaged between 10 and 15 per cent."

Ricker and Foerster (l. c.) set a good example in the matter of defining their terms and employing them consistently. There is need, perhaps, for an early symposium on the terminology of this science.

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Reviews.

H. U. Sverdrup, M. W. Johnson, and R. H. Fleming. "The Oceans; their Physics, Chemistry, and General Biology." pp. 1060, text-figs. 265, 7 charts. Prentice Hall, New York, 1942 (George Allen and Unwin, London).

Six years after publication this book needs no advertisement, and the newcomer scarcely needs to be introduced to it because he will see it on the desks of all his colleagues. It would, however, be an ungrateful omission if this journal resumed publication without affording it some welcoming recognition.

Its wealth of detail and abundant references emphasize the growth and refinement of oceanography during the past 30 years. There is still scope for exploring expeditions to chart the sea bottom and the physical and chemical properties of the water, and it is still relatively easy to discover new species by using a net or dredge at very great depths; but as the subject unfolds, and more precise problems are presented, the work becomes more and more specialized. The oceanographer needs more than great enthusiasm and patience; he needs a thorough technical training and wide knowledge of what has been done before, and will find his work much easier if he has a good knowledge of mathematical techniques which can be of service to all sciences. The research ship, if she is to work far at sea, must have laboratories as well equipped as those on shore.

The authors insist on the close inter-relation of all aspects of the subject and it is fortunate that their book was completed by 1942. Professor S v e r d r u p has left the Scripps Institution, to direct the Norwegian Polar Institute, and Dr. F l e m i n g now directs oceanographical work in the U.S.A. Hydrographic Office. The Scripps Institution has lost no time in resuming its fundamental studies, but it will be a long time before three oceanographers of such wide experience can again get together, and, with their colleagues, produce such an excellent comprehensive work. A book written by such a strong team requires a similar team to review it, and since the reviewer, having heard no adverse comments from other oceanographers, must take the whole burden on his own shoulders, he is obliged to be somewhat superficial in his comments, and his criticisms must not be taken too seriously.

In their description of the oceans and physical features the authors have used the terminology and nomenclature favoured by most members of the committee appointed by the International Union of Geodesy and Geophysics, and they emphasize the need for further classification. They use the term "seamount" for a mountain-like structure rising from the ocean bottom, but it is a relief to see that they do not use "swell", seen in some United States publications before the war, for a long, broad elevation, rising gently from the bottom.

It is doubtful whether any useful purpose is served by the names Arctic Mediterranean Sea, American Mediterranean Sea, and European Mediterranean Sea, because they will not replace the names in general use, and an oceanographer does not need to be reminded of the semi-enclosed nature of these seas.

No book can avoid the existing confusion in nomenclature and examples can be found in this book: Algiers-Provencal Basin is used on one page and Balearic Sea on another; Cayman Basin II is the same as Yucatan Basin, and North Polar Sea, Arctic Sea, and Polar Sea all mean the same. The authors do not use the name Southern Ocean, but they cannot describe the uniform water-ring round the Antarctic Continent without using some comprehensive name and they call it the Antarctic Ocean, defining it as bounded on the north by the subtropical convergence.

The discussion of the physical characteristics of the water emphasizes the importance of lateral and vertical turbulence. Where observations have been closely spaced the temperature and salinity of the sea have shown variations much greater than had been foreseen, and measurements with sensitive current-meters have shown that current velocities vary from second to second. The difficulty of making sufficient current measurements, for sufficiently long periods, from anchored vessels, makes it virtually impossible to obtain a knowledge of ocean currents, without finding a satisfactory method of interpreting the distribution of physical and chemical properties in the light of hydrodynamical theory. A practical account is given of the methods that have been tried, and it is worth noting that there is still no better evidence for assessing the accuracy obtained from the practical application of B j e r k n e s's theorem to the sea than the close agreement between W ü s t's calculations (1924) and P i l l s b u r y's measurements (1889) for the Florida Current, and the measure of agreement between the movements of Atlantic icebergs and the calculations of the Ice-Patrol. The same section gives the first publicity outside the Meteor reports to a new method of finding a suitable reference surface for the application of the theorem, described by Professor D e f a n t. It assumes that the surface of least motion lies in the depth interval within which the spacing of the isobaric surfaces remains more or less the same between adjoining stations. A certain amount of trial and error is necessary to find a continuous surface over a network of stations, but the method as used by D e f a n t gave results in good agreement with independent information.

The long chapter describing the principal currents and water masses begins with the Southern Ocean where the almost planetary simplicity of the water circulation allows sound generalizations to be based on fewer data than elsewhere. The authors believe that the circumpolar currents follow the contours of the isobaric surfaces very closely, and the reviewer believes that this assumption minimizes the meridional components. In drawing conclusions about water movements one usually has to work without complete information of all the processes involved, and the data from one region have to be interpreted by means of indications gained from other regions. Conditions cannot be varied at will, and the nearest approach to an experimental investigation of the importance of a particular factor is to study its influence in other regions where it acts under different conditions. It is useful to have this sort of thing clearly stated and to be given some lead about the influence of wind, density differences, the earth's rotation, and bottom topography. Some of the names used to describe water masses, such as East Southern Pacific

Central Water, may not enter into common usage because most people will be satisfied with something less precise and easier to say.

Professor Ekman has pointed out that the section on Internal Waves does not do justice to the pioneer work of Otto Pettersson. No objection can be taken to the statement that "the first observations which indicated the existence of internal waves were discussed by Helland-Hansen and Nansen (1909)", because the first observations referred to are the short-period variations observed during the 1893—96 voyage of the "Fram", but it was not till 1909 that Nansen and Helland-Hansen, persuaded by their subsequent observations in the Norwegian Sea, were convinced of the reality of internal waves. In the meantime Otto Pettersson had observed the rise and fall of the boundary surface between the poorly saline water from the Baltic Sea, and the more saline undercurrent from the Skagerak, and he observed its tidal periodicity. Although some of Pettersson's theoretical conclusions are open to serious criticism, the 1909 report by Nansen and Helland-Hansen does not do justice to his work, and this injustice seems to be perpetuated in the inadequate reference to Pettersson's work in this book.

Oceanography has advanced too rapidly in the last 50 years to allow a text-book even of this size to include an adequate treatment of historical aspects. One thing which everyone welcomes about the book is that it is not an encyclopædia; it gives some guidance, and therefore cannot be infallible.

The biological chapters make a detailed survey of the factors which control distribution and fertility, and the relations of animals and plants to their environment. It is doubtful whether there is sufficient evidence to warrant the statement on p. 160 that the average conditions in a body of water comparable in size to the Mediterranean Sea do not change from year to year. Other sections of the book deal with the chemistry of sea water, waves and tides, sedimentation, equipment and methods, organic production and bacteria.

In conclusion it may be said that the authors attribute the rapid developments of the past 30 years to refinements in the methods of study, and to the application of the results of laboratory studies and experiments, and their insistence in every part of the book on the need for more observations, suggests that theory has outstripped the work at sea. The book will help in the organization of future expeditions; its full survey of existing knowledge and comprehensive bibliographies will assist in planning the work, and the accumulated experience in the design of research vessel methods and equipment will help in carrying it out. It has already done a great deal to promote research and to increase our knowledge of the oceans.

G. E. R. Deacon.

C. E. Lucas and K. M. Rae. "The plankton of the North Sea in relation to its environment. Part I, the hydrological background in the southern North Sea, 1930—1937." Hull Bulletins of Marine Ecology, Vol. **3**, No. 17, pp. 1—33, Hull, 1946.

This paper gives a very thorough analysis of hydrographical data which provide a physical background against which changes in the plankton, as apparent from the Continuous Plankton Recorder surveys in the southern North Sea, 1932—1937, may be seen. In the absence of any *ad hoc* material for correlation with the plankton records, the authors had to make such use as they could of material taken with other objects in view. As such, they

chose the routine observations at a selection of stations on regular steamship lines in the southern half of the North Sea and at the "Varne" lightvessel. These observations have the advantages of relative uniformity of method as well as spatial and temporal standardization, so that changes from year to year can be assessed adequately. This material has been collected only at the surface, it is true, but the authors present sufficient evidence that at least the surface *salinities*, of which is made the greater use, are, in the area reviewed, fairly representative of conditions in the whole water column, or at least in the upper part of it, so that they should be of value in relation to the distribution of plankton at ten metres depth.

The surface salinities along the selected routes are shown at weekly intervals during 1930—1937 in a very surveyable manner by a simple graphical method, so that one may judge at a glance the trends of salinities in space and in time. Mean monthly salinities along a series of standard stations, forming a "route" along the English Channel, through the Straits of Dover, and into the North Sea, are shown in the same manner and also in time sequence for each of the stations of this "route" separately.

In addition, other sets of abstracted data are shown, viz., frequencies of surface salinities exceeding particular values along some of the routes, month by month during the years under consideration, and also "moving averages" of those frequencies, showing, for certain routes and for the "Varne" lightvessel, the overall trend in the frequency of salinities exceeding a particular value.

After having discussed the basic hydrographical data of the routes separately, each route showing its individual features and seasonal variations, the authors point out that all agree in showing a salinity cycle, with maximal salinities during the winter of 1934—1935. Although there were slight differences in phase, the cycle appears to have been fairly simultaneous over the whole area. In connexion herewith the authors draw attention to the fact that at the same time (winter 1934—1935) the quantities of phosphate available for phytoplankton production reached a *minimum*. Changes in salinity, similar to the one discussed here, were reported from the periods 1920—1922 and 1903—1908.

It seems clear that the main cause of such major salinity changes must be sought in the waxing and waning of Atlantic influence, which in its turn might well be connected with variations of the transport of the Gulf Stream system. The authors point out that while increase of salinity in the central North Sea must have derived largely from the north, those in the Southern Bight and the eastern English Channel must have arrived mainly from the western end of the Channel, in spite of the fact that at times the currents at the "Varne" lightvessel deviated well to the west of north. It is known that deeper currents may be more easterly than those at the depths normally measured at the "Varne", and the authors present sufficient evidence that the main trend of the water is to pass up the Channel and through the Straits of Dover, and that only the most extreme westerly "Varne" current may indicate hold-up or reversal. A very illustrative example of the main movement of the water is the steady passage up-Channel of a large "patch" of less saline water from February to August 1936.

It is the opinion of the present reviewer that the authors have given a very valuable contribution to our knowledge of the hydrography of the southern North Sea and the English Channel. Moreover, their presentation is an example of clarity and lucidity. As a minor formal remark one might

ask why the authors have chosen not to use the words "hydrography", "hydrographical", but "hydrology", "hydrological", which in more current use apply to freshwater problems.

Regarding the causes of major changes in salinity, the authors did not discuss the possibility of a correlation with year-to-year variations of seasonal precipitation and evaporation. It is known that at least in parts of western Europe (e.g. the Netherlands) the summer and autumn precipitation of 1934 was below normal. Thus, the influence of the Atlantic water may possibly not have been the *only* controlling factor in producing high salinities.

P. Groen.

Håkon Mosby. "The Thermo Sound: an Oceanographic Temperature Recorder". Bergens Mus. Årb. 1943, Naturv. rekke, Nr. 1; pp. 50, Figs. 11, Pl. 1. Bergen, 1943.

In recent years much progress has been made in the development of oceanographical instruments that give a continuous record of temperature and/or salinity at a selected level in the ocean or as a function of depth. The greatest advance along these lines has probably been made in the U.S.A., but a valuable Norwegian contribution has been made by Professor H å k o n M o s b y, who has designed an instrument which records the vertical distribution of temperature down to more than 2000 m.

His "thermo sound", which is about 1 m. long, consists essentially of a hard brass wire, 0·5 mm. in diameter and approximately 80 cm. long, mounted in an invar-steel frame. The brass wire acts as the thermal element and is connected to a pen with a platinum-iridium tip which makes a trace on a circular soot-covered glass plate. This plate is rotated by means of a propeller, which turns as the instrument is lowered vertically through the water, so that a circular trace is obtained. A second circular trace, the zero circle, is recorded by another pen attached to the invar-steel frame. Since only the brass wire expands with an increase in temperature, the distance between the two circles increases as the temperature increases and this distance is therefore a measure of the temperature of the water. The scale value for temperature obtained is about 0·15 mm. per degree C. and the record has to be enlarged before it can be read. A special reading device mounted on a scaling microscope is therefore used.

The author gives a full description of the thermo-sound and the reading arrangement, as well as an account of the calibration of the instrument and the methods of using it and reading the record, before proceeding to a thorough analysis of the principles upon which the instrument has been developed.

The temperature scale value is computed from theoretical considerations and is found to be very near that obtained by direct calibration. The speed of reaction of the brass wire is then examined and it is found that the brass wire of 0·5 mm. diameter can be expected to be capable of recording with a maximum error of 0·5°C. when the instrument is lowered at a speed of 200 cm./sec., provided that the vertical temperature gradient does not exceed 1·04°C./m. Such a gradient is only found in the oceans in the vicinity of discontinuity layers. Experiments in Nordfjord, where a discontinuity existed, showed the speed of reaction to be fully satisfactory, and further experiments in Byfjord showed that only a minute error is introduced if the brass wire is mounted without any insulation between it and the invar-steel frame.

The number of revolutions of the propeller is assumed to be proportional

to the distance travelled through the water, and it is shown that the slip of the propeller introduces an error in the determination of the depth. If the rate of lowering is at a constant speed of at least 1 m./sec., however, this error is very small.

Various tests have been made with the instrument and these have shown that the recording pen is very sensitive and cannot be expected to retain a completely constant position during handling on board ship. This is an important limitation since it means that no reliance can be placed on the absolute values of temperature, although the relative values are reliable. For this reason the instrument must be used in conjunction with reversing thermometers.

A final analysis of the accuracy of the thermo sound, and a postscript, show that the instrument can record the temperature distribution down to 2000 m. in 17 minutes. The accuracy of the temperature determination depends upon the thickness and evenness of the record, on the precision of the reading mechanism, and on the accuracy of the depth determination. It is concluded that in all cases the determinations are probably correct to the nearest 0·1°C. and to less than 1 m. depth, provided that the absolute values of both temperature and depth are checked by additional control measurements. A good record, however, may be accurate to $\pm$ 0·03°C., with a depth error in the uppermost layers of $\pm$ 0·1 m. *A. J. L.*

Henry B. Bigelow and **W. T. Edmondson.** "Wind Waves at Sea, Breakers and Surf." United States Navy Department, Hydrographic Office. H. O. Pub. No. 602. pp. XII & 177, text-figs. 57, 24 plates. Washington D. C., 1947.

This book is a detailed but non-technical discussion of ocean waves; its intention is to assist the practical seaman. Considerable study of ocean waves and surf has been made since 1940 because of the military demands of World War II and this book contains much of the new knowledge.

The authors describe the physical nature of ocean waves, how they are formed in storms, how they travel across the sea, and how they form breakers on the coast. The general statements are illustrated by a large number of practical instances. The authors have avoided any discussion of the mathematical theory of waves and where the results of theory or of experiments are of interest they are summarized in numerical tables. The book contains 37 such tables and 57 diagrams and photographs to assist the text. Some simple methods of measuring waves from shore or aboard ship are mentioned.

A notable feature of the book is an atlas showing how frequently high seas and high swell are encountered during summer and winter throughout all the major oceans. This atlas is described and discussed in full. Its existence is an indication of the great amount of observational work done by ships' officers during the last decade. This is the only atlas of its kind available as yet to the public. Though it has been brought into being for military ends it may well be of value to commerce, since such information is needed in the construction of new harbours and of all engineering ventures exposed to the sea as, for instance, certain new oilfields.

Work in recent years has put much emphasis on the nature of surf. This new work is dealt with in the last three chapters of the book. The size of the breakers on the coast is obviously dependent on the size of the waves or swell coming from the open sea. It is not so well understood that

the surf may vary greatly from place to place on a coast because of the refraction which the waves undergo as they cross the zone of shallower water. A deep-water channel or submarine canyon tends to refract waves away from the beach at its head, and conversely, a submerged promontory tends to focus wave energy on to itself. These effects of refraction and the nature of refraction around islands and headlands are discussed in some detail.

It is also pointed out how the nature of the surf indicates the character of the submerged beach. Further points discussed are the manner in which waves and surf are modified by tidal streams, by the prevailing wind, or by the presence of seaweed or ice.

The book is a useful summary of what is known of waves and surf in practice.

N. F. B.

H. Einarsson. "Euphausiacea. I. Northern Atlantic Species." Dana-Report, No. 27, pp. 1—185, 84 figs. Copenhagen and London, 1945.

The Euphausiacea play a very important rôle in the general economy of the seas since the more abundant species, known as "krill" or "whale-feed", constitute the chief diet of certain whales, seals, birds, and food fishes. In recent years the intensive investigation of the antarctic whaling industry, undertaken by the "Discovery" and other expeditions, has greatly extended our knowledge of the antarctic Euphausiacea. Now Einarsson has undertaken a careful and detailed study of the material collected by the "Dana" and "Thor" expeditions and the first part is an important contribution to our knowledge of the species inhabiting the sub-arctic and boreal parts of the Atlantic Ocean.

First he deals with the larval development of the northern species and of some southern guests. There is a striking resemblance between the development of the Euphausiacea and that of the Peneidea; the changes that occur are so gradual that no break or metamorphosis is apparent. The manner in which the pleopods develop in the various furcilia stages is represented by useful formulae; certain paths tend to predominate either in a whole genus or in a natural group within a genus. Coastal species show greater variety of furcilia stages (and, even within one species, more varied numbers of moults) than the oceanic ones. The adults are next described and a useful key to the determination of the species is given. I note with interest that the thelycum or spermatheca of the female proves to be a character of taxonomic importance where the petasma of the male has hitherto been used; this also holds good for the Peneidae and, as I recently found, in the family Homolidae (Dromiacea) as well. The absence of a thelycum in *Nyctiphanes couchii* (Bell) is surprising; spermatophores similar to those of other Euphausiacea are formed, but the petasma is less highly developed than in the other species figured. Moreover, this species seems to have extended its northern range in recent years. The "*neglecta*" form proves to be a transitory late larval and post-larval phase in the development of *Thysanoessa inermis* (Krøyer) which, in rare cases, may be retained in the mature adult.

The major part of the paper deals with the distribution of the various species under the following headings:— spawning and distribution of the larvae; horizontal distribution of adolescents and adults; vertical distribution; and factors controlling distribution. The six species that breed in the area under consideration appear, for the most part, to occupy different ecological niches. Swarming occurs at times other than the spawning season and is

determined by hydrographical conditions, notably by the ocean currents. Spawning is apparently dependent not on the temperature but on the growth of the phytoplankton, and E i n a r s s o n suggests that certain chemical substances produced by the growing plant-life may act as the stimuli. A close correlation exists between temperature and the age at which sexual maturity is reached; at lower temperatures the rate of growth is relatively faster than the rate of development. In the genus *Thysanoessa* the thelycum and petasma undergo regression after mating and spawning have taken place but it is not known whether the adults survive to breed a second time.

The value of the paper is enhanced by the excellence of the drawings, diagrams, and maps with which it is illustrated. *I. Gordon.*

L Fage. "Mysidacea: Lophogastrida — I" : — II". Dana-Rep. Nos. 19 and 23, 52 pp., 51 figs., and 67 pp., 42 figs. Copenhagen and London, 1941 and 1942.

In these two papers Professor F a g e deals with the more primitive of the sub-orders of the Mysidacea. For a long time it was thought that many of the lophogastrid species must be rare. It now transpires that these pelagic shrimps, being powerful swimmers, easily evade trawl or dredge and that special nets hauled at speed are essential for their capture in quantity. The "Dana" was admirably equipped for this work at all depths down to 5,000 metres (length of cable 7,000 m.) and reaped a rich harvest. For example *Ceratolepis hamata* G. O. Sars, hitherto known only from the "Challenger" holotype, is represented by 174, and the bathypelagic genus *Gnathophausia* by 875, specimens.

Unlike the Euphausiacea, the mysids do not shed their ova freely into the sea but carry them in a brood-pouch till the post-larvae hatch out. Ovigerous females were rare even in this rich collection and, since the "Dana" never worked on the bottom, it is probable that the females of many species live near or on the ocean floor while the larvae are developing.

In addition to the systematic work, Dr. F a g e has made a detailed study of the distribution of each species, whenever possible. Most species of the genus *Lophogaster* live over the continental shelf or around oceanic islands, being most abundant around 200 metres. The adults live near, or occasionally on, the bottom and at least some migrate vertically upwards near to the surface at night: the early post-larval phases are passed in the upper layers. Under the influence of the ocean currents, each coastal species finds its own niche and there is a multiplicity of forms showing slight but constant differences.

A few surface pelagic species, such as *Ceratolepis*, require special warm conditions both as adult and young. They live between 200 metres and the surface but above deep water and are as strictly confined to an upper warm layer centred round the Fiji Islands as are the coastal species to their shallow habitats.

The truly bathypelagic species, on the other hand, are widely distributed in all the oceans. At first sight it would seem as if they ought to be cosmopolitan in their range, but this is true only of those species which never leave the abysses at any stage of their life. Many must spend the post-larval and early adult stages in the upper, warmer layers; these are influenced by climate and ocean currents and are essentially tropical species. Since they all occur in the East Indian Archipelago, Dr. F a g e thinks that these members of the somewhat archaic genera *Gnathophausia* and *Eucopia* are relicts of a rich

fauna which was widely distributed in all tropic seas at the beginning of the Tertiary period.

The effect of environmental conditions on certain species is also discussed. For example, those species which are found on both sides of the Isthmus of Panama become sexually mature later and reach a far greater maximum size on the Atlantic side, where the water is much richer in oxygen, than on the Pacific side.

The author is to be congratulated on the excellence of these well illustrated papers.

I. Gordon.

N. S. Jones. "Observations and experiments on the biology of *Patella vulgata* at Port St. Mary, Isle of Man." Proc. and Trans. Liverpool Biol. Soc., Vol. **56**, pp. 60—77, 2 figs. Liverpool, 1948.

Dans ce travail l'auteur relate les observations qu'il a pu faire sur la biologie de la Patelle (*Patella vulgata*) à Port St. Mary dans l'Ile de Man. L'habitat y joue un rôle important puisque selon les facies la fixation des larves, la croissance, la densité de la population, le régime alimentaire, et les déplacements des individus diffèrent parfois très sensiblement.

La fixation des larves est moindre sous les fucus que dans les flaques mais la croissance y est plus rapide au cours de la première année. La taille moyenne est faible dans la zone des balanes mais la densité y est élevée alors que la taille moyenne est forte mais la densité faible sur le rocher nu. Dans la zone des fucus on trouve des valeurs intermédiaires.

L'auteur accepte en bloc les conclusions de Fischer-Piette sauf une. Pour lui en effet, ce n'est pas la présence des fucus qui favorise la croissance mais la surface libre dont peut disposer une patelle pour y prélever sa nourriture. Cette conclusion amène Jones a formuler une corrélation inverse entre la taille moyenne et la densité de chaque population. Enfin l'auteur montre la balance écologique qui existe entre les algues et les patelles. Il dénude une large bande de rochers et montre l'établissement des algues sur cette surface puis leur croissance intensive contrastant avec l'aspect du littoral voisin ravagé par les patelles. Jones note à ce propos que ce sont les algues vertes qui apparaissent les premières et favorisent l'établissement des fucus en arrêtant les patelles. Il faudrait ajouter que c'est aussi en partie grâce à l'humidité que ces algues, et en particulier les entéromorphes, entretiennent sur le rocher.

Il serait intéressant de savoir, comme le souligne l'auteur, quelle est la raison de la moindre densité de population notée à Port St. Mary par rapport à celle observée en France dans la région de Dinard. La comparaison avec les divers facteurs étudiés par Hatton lui donnera peut être la solution et viendra ajouter encore à l'intérêt de son travail.

R. Letaconnoux.

Sheila M. Lodge. "Algal growth in the absence of *Patella* on an experimental strip of foreshore, Port St. Mary, Isle of Man." Proc. and Trans. Liverpool Biol. Soc., Vol. **56**, pp. 78—85, 4 figs. Liverpool, 1948.

L'auteur a étudié l'installation de la végétation algale sur une surface rocheuse préalablement dénudée de sa couverture d'algues et de patelles pendant l'hiver 1946—47. La zone choisie s'étendait sur 10 m. de large entre

la limite moyenne des hautes mers de morte eau et celle des grandes marées basses. Dans ces conditions les algues vertes commencèrent à pousser au bout de quelques semaines et, au cours de l'été 1947, toute la zone expérimentée était recouverte d'*Urospora* et de *Chaetomorpha* en compagnie d'*Ulva* et de *Porphyra*, ces dernières prenant rapidement une place prépondérante. Dès la première année *Fucus vesiculosus* apparu dans la zone supérieure puis descendit vers le niveau des basses mers aux dépens de la végétation d'algues vertes au cours de l'année suivante. *Fucus serratus* se développa plus tardivement dans la zone inférieure. Des *Dumontia* et des *Laurencia* accompagnèrent les fucus dont l'épaisse végétation permit à la première espèce de remonter à un niveau plus élevé que son niveau habituel. L'auteur note également chez certains jeunes *Fucus vesiculosus* une conformation anormale des frondes dont le thalle peut être élargi ou posséder des aérocystes particulièrement développés. En fin un tableau détaillé donne niveau par niveau le moment d'apparition de chaque espèce et, une belle photographie aérienne, une vue générale de la station expérimentale.

La pauvreté de la végétation que l'on observe sur ce littoral exposé vient de la destruction par les patelles des spores émises par les algues et l'auteur estime qu'en quelques années cette végétation disparaîtra et que le rivage reprendra son aspect primitif. Cette conclusion s'accorde avec l'opinion de divers auteurs sur l'action des patelles. Les observations rapportés confirment également le fait que, sur une roche dénudée, ce sont d'abord les algues vertes et en particulier les *Enteromorpha* qui généralement s'installent les premiéres et favorisent la colonisation ultérieure du rocher par les fucus.

R. Letaconnoux.

S. M. Marshall and **A. P. Orr**. "Further experiments on the fertilization of a sea loch (Loch Craiglin). The effect of different plant nutrients on the phytoplankton." Journ. Mar. Biol. Assoc., Vol. **27**, No. 2, pp. 360—379, 10 figs. Cambridge, 1948.

Experiments with fertilization on the 18-acre salt-water loch have been continued in 1943—45 in order to test special points and different fertilizers. Phosphorus, nitrate, pH, oxygen, phytoplankton — including μ-flagellates counted on a haemocytometer slide without concentration — and zooplankton were determined. The loch has a rich phytoplankton consisting of diatoms and dinoflagellates with *Peridinium triquetrum* as a predominant species. Fertilizations were made on 18. January and 11. February. The first was followed by a great increase of diatoms while the dinoflagellates did not show a corresponding change. The second fertilization, however, resulted in a decided increase in dinoflagellate population, while the number of diatoms remained about the same, in spite of the fact that the amount of fertilizer added was about three times the usual amount.

A comparison with an arm of Loch Sween, where no fertilizer was added, showed that the changes in phytoplankton population there followed a different course.

Experiments in July and August with sampling at intervals of 1 or 2 days, one with superphosphate alone, one with nitrate alone, and a third with ten times the usual quantity of both, gave the result that the first and second had no significant effect on phytoplankton population. The third experiment resulted in an increase in diatom as well as dinoflagellate population. The conclusion is drawn that only when the needs of the attached algae have been satisfied can phytoplankton utilize any remaining nutrients.

It is also suggested that some of the nutrients are adsorbed by the mud or by non-living material suspended in the water.

During winter attached algae are in this locality of less importance. Experiments carried out at this time to try various kinds af fertilizers showed that commercial ammonium sulphate, ammonium nitrate, and monoammonium phosphate could replace sodium nitrate and superphosphate, which had been used previously.

The zooplankton, which during the first year of fertilization experiments was richer in Loch Craiglin than in the outside loch, diminished in the second year and remained poor thereafter.

It may be pointed out that the loch for the greater part is less than 2 m. deep and that conditions consequently are apt to be highly influenced by the bottom and its plant and animal life, a fact which explains many of the irregularities recorded in the effect of fertilizers.

Interesting observations on the diurnal variation in the *Euglena* population at various depths and measurements of respiration and photosynthesis in the *Euglena* population indicate the need for physiological studies of marine Euglenaceae.

T. B.

L. H. N. Cooper. "Phosphate and fisheries". Journ. Mar. Biol. Assoc., Vol. **27**, No. 2, pp. 326—336, 3 figs. Cambridge, 1948.

An attempt has been made to examine quantitatively the question whether a change in the nutrient resources of an area may be reflected in commercial landings of fish.

A comparison is made between the landings of spurdog (*Squalus acanthias*), which is viviparous and pelagic, at Mevagissey representing the local fishery near Station E_1 in the English Channel, and the landings at Mevagissey, Looe, Plymouth, and Brixham taken together, with the winter maximum of phosphate at Station E_1. A rise in the dogfish landings during the period 1921—1928 was followed by a decrease, especially noticeable about 1930. This falling off in the dogfish landings accords closely with the falling off in the stock of phosphate, known as a change from "elegans" water to the phosphate-poor "setosa" water.

In another example with bottom fish, rays and skates, it is argued that any connexion between phosphate supply and fish stock would be expected to be of such nature that some years would pass before the enrichment of the water with phosphate would be reflected in increased catches of fish. A similar lag would be expected when the phosphate content decreased.

Examination of landings of rays and skates at Mevagissey between 1921 and 1938 demonstrated changes which strikingly supported this view, but the author stresses that the good agreement cannot be considered as a definite proof of changes in phosphate being the main cause of the fluctuations in rays and skates, since so many factors enter into the success of a fishery.

The possible effect of changes in phosphate content upon the invertebrate bottom in-fauna is discussed.

In the last section the problem of fertilizing the ocean is made the subject of a very interesting discussion. It is pointed out that while the phosphate *added* to the land helped to produce 42,000,000 tons of crops and supported 12,900,000 cattle as well as other domestic animals, the same amount of phosphate *present* in the English Channel resulted in the landings of only 76,000

tons of fish. The very low economic efficiency of utilization of phosphate in the sea is demonstrated by the fact that during the many years of intensive fishing in the English Channel, each year only 0·1 % of the available stock of phosphorus has been recovered in a form usable by man.

The author stresses that even if the efficiency of recovery could be increased ten times, the yield would still be much less than could be got from the soil supplied with the same amount of fertilizer. Phosphorus being a minimum nutrient on land, steadily brought into the sea by rivers and sewers, it is to be expected that in years to come the problem will be how to recover phosphorus from the sea, not how to put it in.

T. B.

R. A. McKenzie. "The Canadian Atlantic Halibut Fishery." Fish Res. Board Canada, Bull. No. **71**, 29 pp., 15 figs. Ottawa, 1946.

The author of this paper describes the halibut fishery off the coasts of Nova Scotia and Newfoundland. The name halibut, so he tells us, consists of two parts, "hali", "hole" or "holi", and "but". Some authors claim that the first part refers to "hole", that is, deeps in the sea where these fish are often found, whereas others believe the fish was considered sacred or "holi". In my opinion the latter seems to be the correct view. The old Scandinavian name is "heilagr fiskr". "Heilagr" means the same as "holi" and has no connexion with deeps in the sea. The halibut was regarded, as far back as the Stone Age, as a sacred fish in Norway, which is proved by rock paintings dated several thousands years before Christ. In Catholic times up to the seventeenth century halibut was eaten instead of meat during Lent, and is still used for a special dish in northern Norway at Christmas.

The Atlantic Coast halibut fisheries of the U.S.A. and Canada provide only a small portion of the world's landings; in 1928 the catch was 6 % or 6,095,779 pounds. Most of the halibut was taken by vessels fishing mainly for cod and haddock, but it is also caught by boats specially equipped for halibut fishing. The author describes the type of gear used, and the Canadian Atlantic halibut landings from 1918 to 1940 are given in tables and graphs. From the figures for halibut landings at Canadian ports between 1938 and 1940, the author has succeeded in constructing charts showing the average annual Canadian halibut catch from the different banks, and the average halibut production from these banks in the different months of the year. As the author points out, the fishing is based mainly on other species than halibut, and the maps therefore do not perhaps give a real picture of the halibut's absence or presence on the banks. At any rate the maps give a good picture of the halibut fishing on the different banks.

As far as I know, halibut fishing was of much greater importance in these waters in older times than it is to-day. It would be of great interest if data on the halibut fisheries could be collected for periods farther back than 1918. As we know from other papers, the fishermen of Nova Scotia and Newfoundland were pioneers in the halibut fisheries of Davis Strait and even off Iceland. It is reasonable to believe that this remote fishery resulted from a decline in the halibut stock on the old fishing grounds. Reliable data which could elucidate this point would be of great interest, and biologists working on the halibut would be greatly indebted to the author if he would continue his work and give us all the available information on the old halibut fishery in Canadian and adjacent waters.

Finn Devold.

P. A. Soleim. "Årsaker til rike og fattige årganger af sild." Fiskeridirekt. Skr. **7**. 2, 39 pp., figs. 1—15. Bergen, 1942.

The paper under review deals with the smallest larval stages of the herring and describes experiments made partly in the sea and partly in aquaria with the main object of ascertaining the conditions of nourishment necessary for the survival of the larvae in the stages during and just after the absorption of the yolk-sac. Thus it may be said that the aim of the paper is to examine the statement made by Johan Hjort in 1914 that the very early larval and young fry stages are the critical ones in the life history of young fish.

By means of tow-nettings off the south-western Norwegian coast in spring 1941 the fact that the larvae avoid strong daylight was once more substantiated. Furthermore it was noticed that in certain places great quantities of dead and semi-dissolved tiny herring larvae appeared in the catches, and that in the same places the sea was very poor in nauplii. In one case only dead larvae were caught; in another, 800 out of a total of 845 were dead. These observations are of the greatest interest as they furnish direct proof that the critical stages in the life of the larvae are the very smallest.

By experiments in aquaria it was shown that a vegetarian diet alone was insufficient to keep the larvae alive; for survival, animal food such as nauplii was necessary. On account of the fact that diatoms and algae ("green food remains") were most commonly found in the intestines of the larvae, it had been assumed that phytoplankton constituted the main food of the larvae. The author regards it as most probable, however, that phytoplankton is of little value as food, and that it is taken passively by the larvae as they move through the water, the tiny larvae being unable to shut their mouths.

Further experiments showed that variations in salinity between 22·17 and 33·57 ‰ were of no importance to the development of the larvae within the egg. Variations in the temperature of the water had, however, very considerable effect. The biological zero point of the herring egg was found to be —1·2°C. The higher the temperature (temperatures up to 9°C. were considered) the faster is the development. The product of the time (in days) and the average temperature (reckoned from the zero point) was nearly constant in all the hatching experiments.

The results obtained by the author are of great interest, mainly because they afford proof—from observations in nature as well as in aquaria—that the early larval stage is the most critical and they explain why this is so.

It would have been helpful if in Figures 1—3 and the relevant tables, the author had given the day and year of the observations.

Erik M. Poulsen.

P. G. Corbin. "The spawning of mackerel, *Scomber scombrus* L., and pilchard, *Clupea pilchardus* Walbaum, in the Celtic Sea in 1937 and 1939, with observations on the zooplankton indicator species, *Sagitta* and *Muggiaea*." Journ. Mar. Biol. Assoc., Vol. **27**, No. 1, pp. 65—132, 21 figs. Cambridge, 1947.

Au Sous-Comité du Maquereau du Conseil International pour l'Exploration de la Mer, tenu au laboratoire de Plymouth en 1937, un programme de croisières avait été établi entre les Services des Pêches de l'Eire, de la France, et de la Grande-Bretagne; de Mars—Avril à Juin—Juillet de 1937 à 1939, un certain nombre de navires de ces 3 pays coopérèrent dans les eaux de la Mer Celtique, aux recherches hydrologiques et aux pêches planctoniques. Un

certain nombre de résultats de ce programme de recherches a déjà été publié par des biologistes de ces trois pays.

Le travail présent de Corbin fait suite à un rapport préliminaire publié par l'auteur, en coopération avec Steven, en 1939. En outre, le présent travail donne un compte-rendu de la ponte de la sardine et de la distribution de certains indicateurs planctoniques (4 espèces de *Sagitta* et *Muggiaea atlantica*); enfin de la répartition des températures et des salinités.

Les principaux résultats peuvent être résumés ainsi:—

La reproduction du maquerau, d'après le nombre d'oeufs récoltés, commence à partir de la 2ème semaine de Mars et se termine en Juillet en Mer Celtique, en Août en Manche et en Mer d'Irlande. L'intensité de la ponte passe par un maximum durant la seconde quinzaine d'Avril et diminue rapidement en Mai et Juin.

La frayère se déplace régulièrement vers l'est-nord-est; au début, elle est localisée au rebord occidental du plateau continental; à la mi-Avril, elle s'étend sur la majeure partie de la Mer Celtique avec 2 centres principaux d'activité: vers le sud d'Irlande et l'ouest de la Manche; en Juillet enfin, la ponte est terminée à l'ouest des Scillys.

Les stades larvaires sont récoltés d'Avril à Juillet, avec un maximum d'abondance en Mai et Juin. Comme il fallait s'y attendre, les larves de maquereaux abondent sur les frayères après l'éclosion des oeufs et la distribution des larves est comparable à celle des oeufs, suivant le mouvement de la frayère vers l'est. On récolte des larves en Avril le long des accores du plateau continental et en Juillet seulement à l'est du 8° W. Gr.

Dans le même secteur de la Mer Celtique, et à la même saison, se situe une vaste frayère de sardines. Les oeufs de cette espèce se rencontrent d'Avril à Juillet, avec un maximum en Mai—Juin: depuis la partie occidentale de la Manche (Baie de Plymouth) et la côte nord de Cornouailles jusqu'au 8° W. Gr. à l'ouest. Dans la partie nord-ouest de la Mer Celtique et au sud du plateau continental, au-delà de l'isobathe des 200 m., il n'a pas été observé de frayère. L'abondance des oeufs de sardines a été maxima en Baie de Plymouth et au sud de cette baie.

L'auteur indique les salinités et les températures moyennes et extrêmes de la couche d'eau depuis la surface jusqu'à 25 mètres dans les centres principaux de ponte du maquereau et de la sardine. Pour le maquereau, les salinités ont varié en moyenne de 35·15 à 35·50; les extrêmes de 34·51 à 35·58. Des valeurs aussi basses que 34·51 ont été observées seulement en Mai—Juin 1939 sur la frayère principale du nord, où les salinités furent inférieures à 35·2 $^0/_{00}$ (à la même époque, elles étaient de 35·26 à 35·49 dans le centre de ponte du sud).

L'auteur conclut de ces taux de salure aussi éloignés à la valeur douteuse de la fixation d'une limite de salinité aux frayères du maquereau.

Cependant — sauf une exception — toutes les observations précédentes montrent que la ponte se fait dans des eaux à salinité élevée, supérieure à 35 $^0/_{00}$, ce qui n'infirme nullement les remarques de Le Gall et de Furnestin concernant les "axes transgressifs", suivant lesquels ces auteurs ont observé des pontes maxima.

Sur les frayères de la sardine, les salinités moyennes varient entre 35·18 et 35·36, les extrêmes de 35·03 à 35·52; variations moins amples que pour le maquereau. Les températures moyennes sur les frayères de maquereau étaient de 10·2° à 15·5° (extrêmes 10° à 16·3°) et sur celles de sardines de 9·5° à 15·7° (extrêmes 9·4° à 16·3°) : variations de températures plus amples pour la sardine que pour le maquereau, à l'inverse des salinités.

Enfin, l'auteur examine la distribution de quelques espèces planctoniques dans le même secteur; tandis que *Sagitta lyra* par exemple était cantonné le long des accores du plateau continental, *Sagitta elegans* était abondamment réparti sur ce plateau lui-même.

P. Desbrosses.

G. A. Steven. "Contributions to the Biology of the Mackerel, *Scomber scombrus* L.: Mackerel Migrations in the English Channel and Celtic Sea." Journ. Mar. Biol. Assoc., Vol. **27**, No. 3, pp. 517—539, 6 figs. Cambridge, 1948.

Parmi les 42 espèces de poissons comestibles débarquées dans le nord et l'ouest de l'Europe, dont le *Bulletin Statistique des Pêches Maritimes* fait état, le maquereau est un des douze poissons les plus importants par le tonnage pêché.

Le premier port d'Angleterre et du Pays de Galles pour la pêche du maquereau est Newlyn, et même de 1923 à 1926 ce port a reçu plus de maquereaux que tous les ports de pêche anglais et gallois réunis.

Les bateaux de Newlyn pratiquent la pêche au large à l'ouest des Scillys (drifters à vapeur) et la pêche côtière.

Les années passées et jusqu'en 1926, Plymouth pratiquait une pêche florissante en maquereaux dans le secteur de la Manche.

L'auteur décrit les déplacements des lieux de pêche en Mer Celtique et en Manche occidentale de Janvier à Juillet et les figure sur des cartes par mois et par quinzaines.

Le frai débute en Mars aux accores du plateau continental, la frayère ayant la forme d'un fer à cheval dont les branches sont orientées l'une vers l'Irlande et l'autre vers la Manche. Le maximum se présente en Avril, le fer à cheval s'est déplacé vers l'est, la densité maxima des oeufs pondus étant répartie aux deux extrémités du fer à cheval: vers l'entrée de la Mer d'Irlande et vers l'entrée de la Manche, les mois suivants la ponte continue avec une intensité décroissante, les lieux de ponte se déplaçant progressivement vers l'est en direction des îles Scillys. En Juillet les pontes tardives et résiduelles sont près de terre: en Manche, dans le canal de Bristol et en Mer d'Irlande.

Après la reproduction, en Juillet le maquereau apparaît dans les eaux peu profondes le long des côtes, où il restera dispersé, jusqu'en Septembre, Octobre, ou même Novembre.

Le problème posé est le suivant:— Où passe-t-il l'hiver quand il a disparu des eaux côtières superficielles? On pourrait croire qu'il effectue une migration vers le large à la fin de l'automne de chaque année pour revenir vers la côte au printemps qu'il effectue par conséquent une migration génétique anadrome. Cette manière de voir schématique est loin d'être satisfaisante.

En effet une partie au moins n'effectue pas une telle migration automnale vers le large mais passe les mois d'hiver près du fond dans des eaux peu profondes, — comme l'ont montré les ichtyologistes francais C l i g n y et L e G a l l, ainsi que B u l l e n —: sur le rebord de la fosse centrale de la Manche (par 72 m. de fond) au bord sud du Vergoyer (20 à 32 m.) près des bancs de sable éparpillés au large de Dieppe (20—25 m.) (les "ridens" des pêcheurs français), plus au nord autour de la fosse des Small's et des Saltees où ils sont capturés par les chalutiers français, travaillant par 55 à 90 m. De même le "Salpa" du laboratoire de Plymouth et un autre chalutier ont pêché de maquereaux entre Start Point et Lizard de Janvier à Mars pendant les années 1936 à 1939.

Cligny a montré que les bancs de maquereaux ainsi rassemblés l'hiver près du fond sont très denses et aux contours délimités si bien que deux chalutiers travaillant côte à côte peuvent faire l'un d'excellentes pêches, l'autre des pêches nulles.

Le maquereau adulte est donc un poisson pélagique et migrateur seulement pendant une partie de l'année; cette période pélagique comprend une phase de concentration génétique se déplaçant du large vers la côte et une phase de dispersion trophique côtière. L'hiver, il est démersal. Et il semble qu'il se tienne alors près des dénivellations du fond: près du bord des fosses ou autour des hauts-fonds, on le chalute autour des déclivités ou des bancs de sable sur le plateau continental celte et en Manche.

Les concentrations d'hiver près des dénivellations du fond s'effectuent vraisemblablement dans d'autres secteurs du plateau continental et aussi aux accores de ce plateau vers l'isobathe des 200 mètres. Cette concentration au rebord du plateau continental n'est pas prouvée, mais elle est vraisemblable, car elle s'accorde avec ce que l'on observe sur le plateau lui-même et avec la nécessité pour la masse formidable des bancs de maquereaux de trouver des "quartiers d'hiver"; enfin avec la localisation du début de la ponte en Mars qui est précisément situé en bordure des accores.

Ainsi les maquereaux qui ont hiverné sur le plateau continental près des côtes émigrent vers la frayère en direction du large, venant du nord (côte Irlande) du nord-est (Canal de Bristol) de l'est (Manche) et du sud-est (Côte de Bretagne). Ceux qui ont hiverné aux accores du plateau continental, loin des côtes, émigreraient vers la frayère en direction générale de la côte (venant de l'ouest et du sud. Il n'existe donc pas une simple migration de ponte vers les eaux côtières, une migration anadromique; comme ont cru pouvoir l'affirmer de nombreux ichthyologistes, en particulier Allen, Ehrenbaum, Meek.

Cependant ces auteurs ont en partie raison pour le maquereau de la Mer du Nord, qui fraye près de la côte norvégienne et de la côte suédoise du Skagerak en Mai, Juin, et Juillet: la migration génétique est dirigée vers la côte et en même temps c'est une migration des eaux peu profondes vers les eaux profondes voisines de l'isobathe de 200 mètres (fosse norvégienne). Les frayères sont donc dans des conditions comparables en Mer du Nord, en Manche, et en Mer Celtique: elles sont situées près de la pente du plateau continental, loin des côtes de la Manche et de la Mer Celtique, mais près de la côte de Norvège pour le maquereau de la Mer du Nord.

Selon Steven, il est probable que la reproduction et les migrations s'effectuent dans des conditions analogues pour les populations de maquereau du versant occidental de l'Atlantique Nord.

Quant au maquereau jeune et immature d'Europe, ses migrations et son comportement sont peu connus; il semble bien qu'il s'enfonce vers le fond en hiver et mène une vie pélagique à la même saison que l'adulte; déplacements apparemment moins étendus et moins réguliers que ceux du maquereau adulte.

Cette étude fort intéressante sur les migrations du maquereau, et d'une lecture attrayante pose comme hypothèse de base la recherche d'eaux profondes au-dessus des accores de 200 m. par le maquereau à sa maturité aussi bien en Mer Celtique et en Manche qu'en Mer du Nord. Que le maquereau recherche de telles frayères en raison de la proximité de la dénivellation profonde, nous pourrions l'admettre pour celui qui a hiverné aux accores mais non pour celui qui a passé l'hiver près des hauts-fonds du plateau continental

en Manche, aux Smalls etc..... Les conditions de températures et de salinités ne jouent-elles pas le rôle principal dans la localisation des frayères? L'auteur les a délibérément passées sous silence.

D'autre part l'hivernage aux accores du plateau continental pour une partie du stock est une hypothèse voisine de celle envisagée par J. Le Gall en 1939 qui supposait une concentration de prématuration près des accores (cf. Rev. des Trav. Office des Pêches, Tome XIII, fig. 29).

P. Desbrosses.

A. Marcotte et J.-L. Tremblay. "Notes sur la Biologie de l'Éperlan (*Osmerus mordax*, Mitchill) de la province de Québec." Contrib. Stat. Biol. de Saint Laurent. No. 18; 107 pp., 19 figs, Pl. 7. Québec, 1948.

In this paper, Marcotte and Tremblay deal with the migrations, reproduction, and development of the smelt as well as with the biometrical features of this fish which inhabits two localities with waters differing in salinity and temperature. One of the areas is the long estuary of the St. Lawrence River, where the salinity and the temperature of the water between Québec (fresh water) and the Gulf of St. Lawrence (sea water) vary greatly. The other area examined is Baie des Chaleurs, largely open to the influence of the sea.

There are two migrations of the sea smelt to the coast in the course of the year — the reproductive one in the spring, when the fish enter the river for spawning, and a "trophic" one in the autumn period. Fishing is permitted only in the autumn period. The authors' opinion that the autumnal approaching of the smelt to the coast is governed by the search for appropriate food has not been proved by the examination of the food in the stomach of the fish, so that some other interpretation of this migration is possible. An analogous autumnal migration of the sprat has been observed in the Baltic, where the sprat shoals approach the calm coastal waters for wintering, and during the whole winter season they do not take food, as Mankowski has shown.

Before entering the river for spawning the smelts stay in the vicinity of the river mouth for 2 to 3 weeks. This is a period of adaptation to the new environmental conditions. The sea water temperature at the beginning of the spawning migration varied in different years between 4° and 5°C., while that of the river water was 7°C. The optimal water temperature during the spawning period (10—15 days) seems to be between 7° and 10°C.

During the period of adaptation the smelt covers itself with a thick layer of mucus to protect its "milieu intérieur" against the osmotic effects of the freshwater environment.

The actual spawning is stated to take place only at night. During the daylight hours the fish lie in the deeper hollows of the bottom in the neighbourhood of the shallow spawning ground.

When shed, the ova fix themselves on plants and the bottom and are often subjected to desiccation owing to the marked variation of the water-level in the river during the tidal period.

The number of males fished on the spawning ground is twice as great as that of females. The authors consider this to be a result of the different behaviour of the two sexes. The females leave the spawning place as soon as they have deposited their ova, while the males remain on the spawning place for some time. This opinion is corroborated by the fact that of the spent individuals in the second part of the spawning, 97 % are males.

In the chapter dealing with the development of the smelt descriptions are given of the ova and larvae, in successive stages of embryonic development. These are illustrated by photographs. The larvae are brought down to the sea by the river current. During the first days of sea life the larvae keep to the surface water and later pass to the deeper layers, but remain in the vicinity of the coast. They have never been caught more than one mile distant from the coast.

A closer examination of the smelt from Baie des Chaleurs (sea water) and from the estuary of the St. Lawrence River has revealed differences between the populations from these two areas. The average body-length of the smelt living in the estuary (15·63 cm.) is lower than that of the smelt from the Baie des Chaleurs (19·30 cm.). The number of vertebrae in the smelt from the two areas is also different; in the Baie des Chaleurs it averages 62·15; in the estuary, 60·93.

Furthermore, the authors emphasize the fact that even in the same area there exist several local populations with different biometrical characters, such as body-length, relation between the weight and body-length, number of vertebrae, percentage of males, and fat content. In the estuary of the St. Lawrence River three different populations were examined — at Québec (fresh water), Trois-Pistoles, and Matane (nearest to the open waters of the Gulf of St. Lawrence). The following figures show the differences among these three populations living in different environmental conditions; the temperature in the estuary, from Québec to Matane, gradually falls, while at the same time the salinity rises.

	Average body-length	Number of vertebrae	Percentage of males	Percentage of fat
Québec	14·96	60·48	60·69	13·34
Trois Pistoles	17·10	61·93	48·27	16·10
Matane	14·53	60·93	36·49	17·68

Studies lasting four years have allowed the authors to express some general conclusions as to the influence of external conditions on the characters of the smelt populations:—

a. the body-length of the smelt increases as the salinity of the water rises,
b. the number of vertebrae is the greater, the colder the water is,
c. the average weight of the same body-length class increases gradually as salinity rises,
d. the percentage of males falls as the water temperature decreases,
e. the fat content of the body of the smelt rises with the rise of salinity.

The authors' conclusions would be easier to appreciate if the hydrographical data of the areas studied were given in the paper. Apart from this, the numerous observations collected constitute a valuable contribution to the studies of the life history of fishes.

M. B.

Poul Jespersen. "Indo-Pacific Leptocephalids of the genus *Anguilla*. Systematic and biological studies." Dana-Report No. 22, pp. 1—127, pls. i—iv. Copenhagen and London, 1942.

After the publication in 1922 of the full evidence for the now well-known life histories of the Atlantic freshwater eels, Johannes Schmidt bent his will and energies to the elucidation of the bionomics of the other members

of the genus *Anguilla*. His plan of attack was first to distinguish between the different species and races, then to discover at what seasons they mounted the rivers as elvers, and finally to locate their breeding places in the sea and to trace their larval life and migrations. To the first two ends, he gathered together, with the collaboration of zoologists the world over, a vast number of adult eels and elvers. In a first report on this in 1925 Schmidt established the fact that the genus *Anguilla* was absent from the rivers of the South Atlantic and of the whole western coast of the Americas. In the Indo-West-Pacific several species were found, but it became clear that *Anguilla* was absent from the rivers entering the Gulf of Siam and the shallow seas about it.

The breeding places of the tropical and temperate eels of the Indo-Pacific area were quite unknown. Only two larvae had been found, both from the sea north of Celebes. The Carlsberg Foundation's expedition of 1928—30 was undertaken primarily to find the larvae and to discover the conditions in which spawning and development take place in the life of these blood relations of the European eel.

Schmidt did not live to work out the great collection of material and data brought back in 1930, even so far as it concerned *Anguilla,* but in 1935 the Carlsberg Foundation published an article written by Schmidt just before his death, in which the most striking results of the Indo-Pacific voyage were added to the epic of "Danish Eel-Investigations."

It was left to Schmidt's younger collaborators to finish the task. In 1939 Ege published his "Revision of the genus *Anguilla*" based on the stupendous material of between twelve and thirteen thousand elvers and a like number of adult eels. It was only when this was finished that it became possible to interpret fully the mere 1494 pelagic larvae and metamorphosing stages, and this has now been done for us by Poul Jespersen in the report under review.

It is surely not Jespersen's fault, but the virtue of the interpretative imagination of Johannes Schmidt, that the most spectacular conclusions have already appeared in the article of 1935 already mentioned. For the rest, the "Dana" had only the period from October 1928 to January 1930 to filter through its stramin nets as much as it could of the length and breadth and depth of the whole "Indo-West-Pacific" seas. Add to this the fact that there was no guidance as to possible spawning seasons, and it is not surprising that only four larvae were caught between the Marquesas and New Caledonia, and none in Australian and New Zealand waters. The western Indian Ocean, along the east coast of Africa and around Madagascar, yielded eighteen larvae during two months. The other 1472 larvae came from eastern Indo-Malaya and the eastern Indian Ocean, mainly the waters west of Sumatra. In the countries bordering all these waters Ege has shown that fourteen species of *Anguilla* exist, and this complicates the identification of the larvae. Even off Sumatra the larvae may belong to some or all of four species. Three characters were found to be of diagnostic value in the larvae, the number of myomeres, the distance between the anterior ends of the dorsal and anal fins, and the positions of the main vertical blood-vessels. With the aid of the geographical distribution data provided by Ege's work a large number of the larvae could thus be identified.

The reader who seeks an explanation of the long migration of the European eel will look first for what is common in the life histories of this and its Indo-Pacific congeners. Jespersen's conclusion is that the condi-

tions for spawning in the tropical as in the Atlantic species are, 1. great depths, 2. high temperatures, 3. high salinities in the intermediate layers. Even in the area west of Sumatra, however, it seems to the reviewer that the evidence for a special salinity requirement is not conclusive. It is true that there is a region of rather high salinity at a depth of about 100 metres in the Mentawei Deep, but it is not clear that the larvae at any stage show a preference for this layer, and the depth at which actual spawning takes place is still unknown. It is difficult to imagine why the eels should require seas of very great depth if they do not use the deeper layers. Yet the evidence for the depth requirement seems firmer than that for the others. The high temperature requirement still awaits its most spectacular proof, which would be given by the demonstration of a long migration on the part of the eels of Australia, New Zealand, and Japan. An interesting form is *A. australis schmidti*, which is found in New Zealand and New Caledonia, but which shows a higher average size for the elver in New Zealand. This may be a racial character indicating more than one breeding place.

Not only do the tropical eels show no migration comparable to that of *A. anguilla* but, as Jespersen emphasizes, nearness to land seems to be a definite requirement for these species. For although they are hatched not far from the west coast of Sumatra, eels are absent from all but the northern end of the east coast of that island, and from all the coasts of the shallow sea, from the Gulf of Siam and the Malacca Straits to the Java Sea. This seems to argue a short larval life for these species and it is estimated that two or three months will see them from egg to elver, whereas *A. anguilla* requires as many years. The gap in the distribution of eels about these shallow waters and the purity of the American and European populations of eels are the two facts which seem to the reviewer to support Schmidt's view that the length of the larval life stands in a causal relation to the distribution of the adults, helped, however, by the course of the currents that leave the spawning area. Among the wealth of charts, tables, and frequency diagrams supplied by Jespersen, one looks in vain for a chart showing currents. This is perhaps a premature demand, but speculation on currents is stimulated by the charts of temperature and salinity.

The relation between the main ocean currents and the distribution of *Anguilla* was pointed out by Schmidt in 1925. A more detailed analysis of currents and seasonal oceanography in relation to eel-distribution in the Indo-Pacific is an eventual necessity for the solution of the eel problem. We may look forward to a reconsideration of the whole eel question in the light of new oceanographical data obtained during and since the war. First, however, it still remains for a vessel with tow-nets to be present at the places and the seasons of spawning of three species or groups of species, the east African, the Australian and New Zealand, and the Japanese. Even a two-year expedition had the ill-fortune to miss all of these. It would be a fitting reward for the imaginative insight of Johannes Schmidt and the faithful labours of himself and his collaborators if the elucidation of these final chapters should fall to a Danish expedition too. And may we hope that this time closing nets may be used, and that some means may be devised to catch even the spawning adults? Dr. Bruun has confided to some of us his ambition to catch the sea serpent. Maybe he will at least get an adult *Anguilla* in its spawning area.

After thanking Mr. Jespersen for the fullness of his data and his clear analysis of them, one may grumble a little at the use of the word

"Leptocephalids" in the title. The suffix "ids" is the anglicized form of the ending of Family names, and to a purist "Leptocephalidae" is equivalent to "Congridae." "Leptocephalus-larvae", or simply "larvae", the usage in the bulk of the paper, grates less on the reviewer's ear than either "Leptocephalids" or "Leptocephals" as on p. 9. One notes the restriction, following Strubberg, of the term "glass-eels" to the pelagic metamorphosed stages and the use of "elvers" for demersal coastal or estuarine young only.

E. Trewavas.

Current Bibliography.

Prepared by the Editor.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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